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THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY—VOL. IX.

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REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH

DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD

AND NOW OF

JOHN MURRAY, F.R.S.E.

ONE OF THE NATURALISTS OF THE EXPEDITION

ZOOLOGY—VOL. IX.

TEXT.

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Report on the Foraminfera dredged by H.M.S. Challenger, during the years 1873–1876.

By Henry B. Brady, F.R.S., F.L.S., F.G.S., &c.

(*First instalment of Manuscript received May* 1882; *the last in June* 1884.)

EDITORIAL NOTE.

The Report on the Foraminifera by Mr. H. B. Brady, F.R.S., &c., occupies the whole of the present volume, the text and the plates being bound up separately. The Report forms Part XXII. of the Zoological Series of Reports on the Scientific Results of the Expedition, and is the largest which has been published up to the present time.

The representatives of this group of animals are universally distributed over the floor of the ocean and in the surface and subsurface waters, and moreover the presence or absence of the calcareous shells of certain Pelagic Species in the deposits from different depths and localities is intimately connected with some of the most interesting and intricate problems of General Oceanography.

It was of prime importance for the discussion of these questions relating to geographical and bathymetrical distribution to have a thorough revision of our knowledge of existing species and varieties, and it must be regarded as a fortunate circumstance that a naturalist so familiar with the Foraminifera as Mr. Brady should have undertaken such a very laborious piece of work.

It would be difficult to overestimate the amount of labour involved in a careful examination of the large quantity of material which Mr. Brady took as the basis of his Report, together with the comparison, determination, delineation, and description of the various species and numerous series of forms.

The Report itself is the best evidence of the success which has attended Mr. Brady's investigations, and it is not too much to say that this extensive Memoir will be an indispensable boon to all future workers in this branch of Research.

John Murray.

Challenger Office, 32 Queen Street,
Edinburgh, 8*th July* 1884.

ERRATA.

Page 42 *d*, erase line 4, "MUNIER-CHALMAS, &c."
„ „ line 21, for "der" read "des."
„ 110, „ 2 from foot } for "*Pulvinulina scitula*" read "*Pulvinulina patagonica.*"
„ 117, „ 6 from top }
„ 124, „ 7 from foot, for "*Globigerina borealis*" }
„ 125, „ 5 from top, "*Globigerina borealis*" } read "*Globigerina pachyderma.*"
„ 126, lines 1 and 2, for "*Globigerina bulloides*, var. *borealis*" }
„ 216, line 1, for "[*macropora*, Ehrenberg, sp. ?]" read "[*hemprichii*, Ehrenberg, sp. ?]."
„ 419, „ 2, for "*textilaroides*" read "*textilarioides.*"
„ 444, No. 1 (*Lagena globosa*), for "Walker & Jacob, sp." read "Montagu, sp."
„ 450 „ (*Lagena globosa*), for "(W. & J.)" read "(Montag.)."
„ 455, line 13, erase "pl. xxvi. fig. 2."
„ 462, „ 11, for "*villardeboana*" read "*vilardeboana.*"
„ 502, erase line 3 "(*Dentalina prælonga*, &c.)."
„ 534, line 6, for "*Sphincterulus*" read "*Spincterules.*"
„ 553, „ 16, for "*gutticossata*" read "*gutticostata.*"
„ 570, „ 11, erase "pl. xi."
„ 660, „ 16, for "*variolaria*" read "*variolata.*"
„ 688, „ 7 from foot, for "*Rotalia*" read "*Rotalina.*"

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the FORAMINIFERA collected by H.M.S. Challenger during the Years 1873-1876. By HENRY BOWMAN BRADY, F.R.S., F.L.S., F.G.S., &c.

INTRODUCTION.

THE following Report consists mainly of a description of the Foraminifera furnished by the various bottom-dredgings and tow-net gatherings obtained during the Challenger Expedition. As dredging was conducted at more or less regular intervals during the entire voyage, the material collected by that means affords a general indication of the nature of the sea-bottom, both with respect to its physical and biological features, over a considerable portion of the globe. Those regions of the North Atlantic, however, which were explored on the "Porcupine" Expedition of 1869 were not visited on the Challenger cruise; and as no detailed account has hitherto been given of the Foraminifera procured at that time, it has been thought desirable that, as far as possible, they should be included in the present work. To add somewhat to its completeness with reference to recent scientific expeditions, the collections made on the cruise of the "Knight Errant" in the summer of 1880 and on the British and Austro-Hungarian North-Polar Expeditions have also been utilised.

Observations were taken during the Challenger voyage at three hundred and sixty-two Stations, but from a number of them only small samples of the sea-bottom were preserved; whilst, on the other hand, shallow-water gatherings were frequently made which do not appear in the official list. The material practically available for the purposes of the present Report consisted of sands, muds, and the like, from about one hundred and

forty Stations, and was of widely representative character, whether as to locality, depth of water, chemical composition, or physical aspect. Unfortunately but little attention was given to the collection of shore-sands, and the chief deficiency so far as the Foraminifera are concerned is in the species affecting the littoral zone. The dredgings, for the most part, were preserved in alcohol; some few, however, were merely dried.

The tow-net also was employed very constantly during the voyage, and the various gatherings of surface-organisms were in like manner preserved in alcohol. A large number of mountings were made on shipboard from the richer hauls, and these have since formed the most valuable source of information respecting the pelagic Foraminifera.

The "Porcupine" dredgings concerning which sufficiently accurate particulars could be obtained were referrible to about twenty-four Stations in the North Atlantic, and the material as it reached my hands consisted entirely of dried sands and muds. The Arctic soundings to which allusion has been made were in the same condition. The "Knight Errant" collections were brought home in alcohol.

The observations made by the Challenger staff upon freshly collected surface-specimens of *Globigerina*, *Orbulina*, *Hastigerina* and *Cymbalopora*, together with the figures drawn from the living organisms, have been to some extent embodied in the descriptive portions of the Report; but, except with respect to the pelagic species, there has been but little to record concerning the actual life-history of the group. The nature and condition of the preserved material have, for the most part, precluded any satisfactory investigation as to the anatomy and organization of the soft parts of the animal; hence, so far as the study of individual specimens is concerned, the following pages are chiefly devoted to matters relating to the external skeleton or test, its minute structure and general morphology, and the zoological relations dependent thereupon.

The examination of material collected under such diverse conditions has naturally resulted in the discovery of many species and even genera previously unknown; and there is scarcely a Family of the Foraminifera that has not been materially enriched thereby. The most noteworthy additions both as to number and importance have been amongst the forms which build for themselves composite tests in place of the usual calcareous skeleton,—a group of Foraminifera concerning which our knowledge has been much extended of late years. Hitherto these "arenaceous" types have been variously treated by different systematists, having been recognised by some as constituting a distinct Sub-order, whilst by others they are not admitted to any collective position. Under these circumstances the subject of Classification has demanded fuller treatment than might otherwise have been needful, and a separate chapter has been devoted to its consideration.

Much attention has been bestowed upon the distribution of the various genera and species, whether geographical, bathymetrical, or geological, and a complete or approximately complete list of the Foraminifera occurring in each batch of material has been preserved. The number of Stations forbids any attempt to arrange the whole, or indeed

any large proportion of these lists in the form of a general synopsis. The Distribution Tables given at the end of the volume are intended chiefly to illustrate the Foraminiferal fauna of the various classes of oceanic deposits—a point concerning which scarcely anything has hitherto been written. The first Table affords a comparative view of the Foraminifera of all the better known deposits, whilst the second and third refer particularly to the two most important and most widely diffused, namely, Globigerina Ooze and Red Clay. To these have been added a Table of the Foraminifera inhabiting shallow water in high latitudes, north and south.

Beyond this general statement as to the scope of the Report, but little is needed by way of introduction. There are, however, certain matters of general interest to which attention has been directed during the investigations connected with it—such, for example, as the relation of the surface-fauna to that of the sea-bed, the chemical composition of the test in the various groups of Foraminifera, and one or two points relating to the morphology of the test—for which there is no very obvious place in the body of the memoir, and to these I propose to devote a few preliminary observations.

But before proceeding further I have a pleasant duty to perform, and that is to express my thanks to many of my fellow-labourers in the same field of research, for the assistance which they have been ever ready to extend to me during the progress of the work, and of which I have so often been glad to avail myself. To my old friends and colleagues Professors W. K. Parker and T. Rupert Jones I am beholden for notes and suggestions too numerous to particularize; and to Prof. Rupert Jones, in addition, for his efficient help in the revision of the proof-sheets. To Dr. Carpenter I am indebted for the use of the fine collection of arenaceous Foraminifera obtained on the "Porcupine" Expedition; and to the kindness of the Rev. Dr. Norman I owe a considerable part of my supply of dredged material from the same cruise, as well as the loan of many mounted specimens from other sources. I am glad also to have the opportunity of acknowledging the friendly assistance rendered by Dr. Karrer of Vienna, especially in matters pertaining to the Bibliography. There are many others from whom I have received valuable aid in connection with particular portions of the Report, due recognition of which will be found in subsequent pages. Amongst those to whom I am thus indebted are Prof. Seguenza, of Messina; Dr. Schwager, of Munich; M. Schlumberger, of Paris; Mr. H. J. Carter, F.R.S., of Budleigh Salterton; Mr. David Robertson, F.G.S., of Glasgow; Mr. Joseph Wright, F.G.S., of Belfast; Mr. J. D. Siddall, of Chester; Mr. F. W. Millett, of Marazion; Mr. J. T. Dunn, M.Sc., of Newcastle-on-Tyne; and Dr. C. R. A. Wright, F.R.S., of London. My thanks are due, and in no stinted measure, to Mr. A. T. Hollick, for the care and pains which he has bestowed upon the accompanying plates. With a very few exceptions the figures were originally drawn in more or less detail by myself; but in the transfer to stone the whole have been re-drawn by

Mr. Hollick direct from the specimens; and it is sufficient to add that this has been done with his customary fidelity.

I would that there were more to show for so large an amount of friendly interest and co-operation. The Report, lengthy though it appears, has no pretence to completeness, indeed a lifetime might be spent upon the collections of which it treats without exhausting their points of interest. But in a publication of this sort there are certain limits as to time which must be respected; and the present volume is offered as an instalment in which the details of the subject have been pursued as far as has been practicable in the time that has elapsed since the return of the Expedition. The method of treatment has been made as comprehensive as possible, in the hope that the results may be of service as a starting-point for further research.

It is perhaps needful to mention that the drawing of the specimens was commenced at a very early stage of the work, and that a considerable number of the plates had been lithographed and printed off before the whole of the material had been fully examined. By no other plan could serious delay have been avoided. For the same reason the various sections of the manuscript were consigned to the printers as soon as they were completed. There are many disadvantages attending this method of proceeding, the most serious of which is the liability to discrepancies between the earlier and later portions of the work, owing to the progress of research in the interval. In the present case the discrepancies happen to be of comparatively slight practical importance. The most noticeable are in connection with the generic names inscribed on the plates, which in a few instances do not exactly correspond with the heading of the "Explanation," the latter having been printed at a much later date than the plates themselves. The inconsistencies in the letterpress due to similar causes appear to be confined to certain small matters of nomenclature, which are enumerated with the "Errata."

The term *Foraminifères* was originally employed by d'Orbigny in the Tableau méthodique de la classe des Céphalopodes,[1] at a time when the Foraminifera, or at least a considerable section of them, were looked upon as microscopic Mollusca. In the work alluded to, the class Céphalopodes was divided into three Orders—I. *Cryptodibranches*; II. *Siphonifères*; III. *Foraminifères*; and of these the last two, which comprised Mollusca with chambered shells, were respectively distinguished,—the *Siphonifères* by possessing a continuous central tube or siphon, the *Foraminifères* by having chambers

[1] *Annales des Sciences Naturelles*, vol. vii., 1826, p. 245.

"IIIe Ordre.—Foraminifères, Nob.; *Asiphonoïdes*, de Haan.

"*Caract. essent.*—Un test polythalame totalement interne; dernière cloison terminale; point de siphon, mais seulement une ou plusieurs ouvertures donnant communication d'une loge à l'autre."

communicating with each other by an aperture or foramen (sometimes by more than one) in each septum.

There is little in d'Orbigny's classification or in his definition of the Order that commends itself to the student of the present day, and it is even probable that the term "Foraminifera" is more commonly associated with the general perforation of the shell-wall, which is a conspicuous feature of one division of the group, than with the character it was originally designed to indicate; nevertheless, it is certain that no other name which has been suggested—whether *Rhizostomes*, *Polypodes*, *Trematophores*, *Asiphonoïdes*, *Polythalamia*, or *Thalamophora*—has found the same acceptance amongst naturalists. The term *Polythalamia* is almost invariably used by Ehrenberg and occasionally by Max Schultze, but by others it has been seldom employed except as an alternative; and it is open to the objection that, from an etymological point of view, it is not strictly applicable to an assemblage of organisms of which a considerable proportion are monothalamous.

It may be questioned whether our knowledge of the structure and life-history of the animals constituting the Order is sufficiently extensive and well established to be used as the basis of a name, the number of types concerning which we have any information beyond that derived from their dead shells being comparatively small; but, so far as is known, the term "Rhizopoda Reticulosa" or "Reticularia," suggested by Dr. Carpenter and adopted by Prof. F. E. Schulze and others, is perfectly appropriate.

At the same time we may remember that it is to d'Orbigny we owe the first recognition of the Foraminifera as a distinct zoological group, as well as the researches which gave the first impulse to their independent study; and, in absence of any weighty argument to the contrary, rule and custom alike suggest the acceptance of the name given by him and already generally adopted.

Prof. R. Hertwig limits the application of the term Foraminifera to those forms which possess a perforated calcareous test;[1] but, as has been before explained, the designation does not refer to general shell-perforation, but to the existence of stoloniferous orifices, and in this sense it is equally true of all polythalamous species whether otherwise "perforate" or "imperforate." Nor is there much violence to d'Orbigny's original idea in accepting the orifice of *Lagena*, or analogous types, as a "foramen," though in the absence of any succession of chambers it serves only for the passage of pseudopodia. On these grounds, therefore, either the term "Foraminifera," derived from the shell or other investment, or "Reticularia," suggested by the distinctive character of the sarcode-body, is a sufficiently accurate appellation for the group, but the former has the right of priority.

Genera and Species—Nomenclature.—Much has been written concerning the existence or non-existence of true species amongst the lower Protozoa, and especially amongst

[1] Der Organismus der Radiolarien, 1879, p. 142.

the Foraminifera. The abstract question has but little claim on our attention, but connected therewith are certain practical points which invite a moment's consideration. From a purely biological standpoint, the views expounded by Dr. Carpenter and his colleagues, in the Introduction to the Study of the Foraminifera,[1] are for the most part incontestable, but they embody only one aspect of the subject.

It has been said by Prof. Huxley, speaking of the classification of the Invertebrata generally, that we may expect "the progress of knowledge will eventually break down all sharp demarcations and substitute series for divisions."[2] Abundant evidence may be found in the pages of the present Report of the completeness of the morphological series in certain families of the Foraminifera. In some families not merely reputed species but reputed genera are connected by a close array of intermediate modifications, with characters differing only in degree of development, as well as by dimorphous forms in which the typical features of allied genera are combined; and in such cases it is not too much to say that "all sharp demarcations" have ceased to exist. There are other groups, however, in which, possibly owing to our defective knowledge, the successive modifications appear to be less closely connected and to possess distinctive characters of greater persistence.

But admitting the intimate relationship which often prevails throughout an entire generic group, admitting even that all the members of a genus may be referred to a common ancestral type, the question still remains how the different terms of each series are to be recognised. The various modifications which have been referred to differ not merely in details of form and structure but in habit; they are met with under diverse conditions as to latitude, depth of water, nature of sea-bottom, and the like, and their modes of life are often totally distinct; furthermore, fossil specimens with similar peculiarities appear to have existed under precisely corresponding circumstances. Whether "species" or not, the more important of them possess characters which afford means of easy identification, and it is obviously necessary that they should be provided with distinctive names. It only remains therefore to be determined what system of nomenclature is to be pursued.

An attempt has been made by Messrs. Parker and Jones, in their elaborate memoir on North Atlantic Foraminifera, to indicate the complicated relationship of the various modifications of the generic and subgeneric types, by the names assigned to them. The result is interesting from a biological point of view, but cannot be regarded as otherwise satisfactory. Such terms as "*Lagena sulcata*, var. (*Entosolenia*) *globosa*" or "*Pulvinulina*

[1] "The ordinary notion of *species* as assemblages of individuals marked out from each other by definite characters that have been genetically transmitted from original prototypes similarly distinguished is quite inapplicable to this group; since, even if the limits of such assemblages were extended so as to include what would elsewhere be accounted genera, they would still be found so intimately connected by gradational links that definite lines of demarcation could not be drawn between them."—Introd. Foram., preface, p. x. Passages of similar import occur at p. xi, p. 56, and elsewhere in the same work.

[2] *Journ. Linn. Soc. Lond.*, vol. xii. (Zoology) p. 226.

repanda, var. *menardii*, subvar. *pauperata*," are something more than names; and resemble too much the descriptive sentences which did duty with the præ-Linnean writers to find general acceptance. Some of the difficulties inseparable from this mode of writing may be gathered from the examples above quoted. For instance, if *Lagena* is to be treated as the typical and *Entosolenia* as a subordinate group, the immediate relationship of *Entosolenia globosa* is with its ectosolenian form, *Lagena lævis;* so that to be complete the name should be *Lagena sulcata*, var. *lævis*, subvar. (*Entosolenia*) *globosa*. Again, it may be true that *Lagena sulcata* is the original type of the genus and *Lagena lævis* the variety; but, judging from the Silurian and Carboniferous specimens, the converse is at least equally probable; and there are some who would prefer to regard the simpler smooth-shelled organism as the type, and the forms with superficial ornament of one sort or other as varieties; and this view would involve a change affecting the entire generic series. The second example is open to similar objection. To speak of *Pulvinulina pauperata* as a sub-variety of *Pulvinulina menardii* involves an assumption which, so far as I am able to judge, is founded on inference rather than on observed facts. The distinctive features of *Pulvinulina pauperata* are remarkably constant, and I have never met with a specimen, at any stage of growth, with characters presenting the least approximation to those of *Pulvinulina menardii*.

Thus, whilst recognising fully the value of the plan introduced by my friends, the authors referred to, of grouping the almost endless varieties of the Foraminifera round a small number of typical and subtypical species, as a method of study, and indeed as almost the only means of obtaining a serviceable knowledge of the entire Order, I have been unable to follow them so far as to make it a basis of nomenclature.

It is surely not requisite for purposes of this sort that a uniform standard of fixity of characters should be adopted; or that a set of beings of low organisation and extreme variability should be subjected to precisely the same treatment as the higher divisions of the animal kingdom. The advantages of a binomial system of nomenclature have not diminished since the days of Linnæus, though the views of the naturalist as to what constitutes a "genus" or a "species" have changed and will probably continue to change; but be that as it may, the Linnæan method is too simple and convenient to be abandoned without some better reason than the different value of these terms, as employed in different zoological groups. The practical point upon which all are agreed is that it is impossible to deal satisfactorily with the multiform varieties of the Foraminifera without a much freer use of distinctive names than is needful or indeed permissible amongst animals endowed with more stable characters.

That specific names have been needlessly multiplied becomes manifest on a very slight acquaintance with the literature of the subject; indeed the process of re-naming has been carried to such an extent as to be a source of constant embarrassment to the student and an obstacle to the progress of knowledge. The lists of synonyms appended to the

descriptive portions of the text might have been very much extended, but the intention has been to limit them to cases in which the identity of the forms referred to is unmistakable; and they are sufficient to indicate the difficulties that have been created by the introduction of useless names, and the need that exists for the revision of the generic and specific nomenclature.

Dimorphism.—The terms "dimorphism" and "dimorphous," which are of frequent occurrence in works on the Foraminifera, have been used in connection with two distinct phenomena, and appear to require a few words of explanation.

In their original sense these terms refer to shells exhibiting two modes of growth. Amongst the LAGENIDÆ, for example, it often happens that two allied genera, differing chiefly in the arrangement of their segments, are connected by an intermediate group which partakes to a greater or less degree of the morphological characters of both. Thus the characters of *Cristellaria* and *Frondicularia* are displayed by the dimorphous type *Flabellina*, the early chambers of which are planospiral, whilst the later segments are embracing and form a complanate rectilinear series. In the same way, *Dimorphina* presents the characters of *Polymorphina* and *Nodosaria*, the early segments forming an elevated spire, the later ones a single row, either curved or straight. It is sometimes difficult to say to which genus the intermediate forms more properly belong (perhaps no general rule applies), and it has been usual to treat them collectively as distinct genera and subgenera. Other examples of dimorphism are found amongst the TEXTULARIDÆ, but under somewhat different conditions from those which have been cited; and though manifested in a variety of ways it does not result in the formation of the same sort of intermediate groups. The dimorphism of the TEXTULARIDÆ depends, generally speaking, upon the tendency of the normally multiserial test to assume a simpler arrangement. Thus, a test biserial at its commencement becomes uniserial in its later growth (*Bigenerina*); one triserial to begin with becomes biserial (*Gaudryina*), or uniserial (*Clavulina*), and so on. In rare instances, examples of "trimorphism" may be met with, as in one of the elongated varieties of *Spiroplecta*, the segments of which are arranged planospirally at the commencement, subsequently as an alternating binary series, and finally in a single line.

"Dimorphism" therefore, as understood by d'Orbigny, Parker and Jones, Carpenter, and others, implies the existence of two modes of growth in the individual shell.

The recent interesting researches of MM. Munier-Chalmas and Schlumberger on the "Dimorphism of the Foraminifera" refer to quite another feature of the Order, namely, to the occurrence of the same species in two distinct forms. The late Dr. Philippe de la Harpe was the first to observe that there were certain Nummulites which were usually, if not invariably, distributed in pairs; and that these pairs, whilst agreeing as to general external characters, differed in point of size; furthermore that the internal structure of the

two associated forms, though alike in other respects, presented one constant difference, namely, that the smaller shells had a large primordial chamber, whilst those of the larger variety had no recognisable primordial chamber, or one of very small size. The two forms were, however, in every case treated by de la Harpe as distinct species.[1] The more extended observations of M. Munier-Chalmas upon the genera *Nummulites* and *Assilina*[2] led to a somewhat different view, namely, that the difference was one of development only, and the "pairs" were two forms of the same species. The recent researches of the same author and of M. Schlumberger, upon other genera of Foraminifera, have revealed the existence of somewhat similar pairs amongst the Biloculine, Triloculine, Quinqueloculine, and Fabularian *Miliolæ*.[3]

The last-named authors offer two hypotheses by which these facts may be explained, but reserve their conclusions for a future paper. It is nevertheless worth mentioning that, in a later memoir, Dr. de la Harpe, after noting the occurrence of *Nummulites* in couples, as already described, and indicating that a different spiral measurement accompanies the diminution or apparent absence of the primordial chamber, though expressing no definite opinion on the subject, suggests that he should have been inclined to regard the difference between the corresponding shells as one of sexual character, had it been clear that any distinction of sex existed amongst the Protozoa.[4]

Pelagic Species.—One of the subjects brought prominently into notice by the observations taken on the Challenger Expedition is the relation of the surface-fauna of the ocean to that of the bottom-deposits. So far as the Foraminifera are concerned the question is by no means a new one; but the Challenger collections, and those more recently made by Mr. Murray on the cruises of the "Knight Errant" and "Triton," have brought many fresh facts into notice, and furnished new ground for its discussion.

The Foraminifera as a rule are not of pelagic habit. On the contrary, by far the larger proportion, probably 98 or 99 per cent. of the known recent "species" or "varieties," including the whole of the porcellanous and arenaceous groups and the bulk of the hyaline forms, inhabit the sand or mud of the sea-bottom, and are endowed with no swimming or floating powers. This may be regarded as a well ascertained fact. But, on the other hand, there are a certain number of forms belonging to eight or perhaps nine genera, which it is equally certain pass their existence, either in part or entirely, at the surface of the ocean or in mid-water. The practical importance of these comparatively few species is due to the extraordinary abundance in which they are found, and the relatively large proportion of the entire mass of the bottom-deposit which is made up of their shells.

[1] *Bullet Soc. Vaudoise Sci. Nat.*, 1879, vol. xvi. pp. 229, 230.
[2] *Bullet. Soc. géol. France*, 1881, sér. 3, vol. viii. p. 300.
[3] *Comptes rendus*, 1883, vol. xcvi. pp. 862, 1598.
[4] *Bullet. Soc. géol. France*, 1881, sér. 3, vol. ix. p. 171.

The following is a complete list of the pelagic forms taken by means of the tow-net during the Challenger voyage.

Globigerina bulloides, d'Orb.
„ *dubia*, Egger.
„ *inflata*, d'Orb.
„ *rubra*, d'Orb.
„ *sacculifera*, Brady.
„ *conglobata*, Brady.
„ *æquilateralis*, Brady.
Orbulina universa, d'Orb.
Hastigerina pelagica (d'Orb.).
Pullenia obliquiloculata, P. & J.
Sphæroidina dehiscens, P. & J.
Candeina nitida, d'Orb.
Pulvinulina menardii (d'Orb.).
„ *tumida*, Brady.
„ *canariensis* (d'Orb.).
„ *crassa* (d'Orb.).
„ *micheliniana* (d'Orb.).
„ *patagonica ?* (d'Orb.).
Cymbalopora bulloides (d'Orb.).
Chilostomella ovoidea, Reuss.

The claim of *Chilostomella ovoidea* to a place in the list is based upon a single specimen, the occurrence of which may have been due to accidental causes. *Cymbalopora bulloides* has only been met with near land in the neighbourhood of coral-reefs, and there is some doubt as to how far it is under all circumstances a pelagic species (see p. 639). Of *Candeina nitida* as a surface-form little can be said; the specimens hitherto obtained, perhaps not more than half a dozen in all, are of very small size and thin-shelled. Some doubt also attaches to *Pulvinulina patagonica*, of which the examples are few, and lacking in distinctive features. These four species stand somewhat apart from the rest of the category, and need not be further considered.

Of the genus *Globigerina* the list includes all the more abundant recent species except *Globigerina pachyderma*, to which we shall presently revert. *Globigerina dutertrei* resembles the typical *Globigerina bulloides* too closely to be readily distinguished in balsam mountings; and the absence of *Globigerina digitata*, which, though widely distributed as a bottom-species, is never found in large numbers, and of the other comparatively rare forms, is in no way remarkable. *Orbulina* is represented by the common *Orbulina universa;* the thick-shelled *Orbulina porosa* with its reticulated exterior being only known by scarce bottom-specimens.

Hastigerina is probably exclusively a pelagic genus, the bottom-specimens, wherever found, being manifestly dead shells, generally broken and invariably much altered in appearance. Of the *Pulleniæ*, one species, *Pullenia obliquiloculata*, occurs not unfrequently at the surface, whilst the two smaller and much more widely dispersed forms, *Pullenia sphæroides* and *Pullenia quinqueloba*, are only known by dredged examples. Turning to *Sphæroidina*, the thick-shelled *Sphæroidina dehiscens* with its coarsely tubulated walls is found, though somewhat sparingly, at the surface, whilst the thin-shelled, finely porous *Sphæroidina bulloides* has never been collected in the tow-net. Lastly, *Pulvinulina* contributes at least five tolerably well-defined species to the surface-fauna, all pertaining to one section of the genus; two of these, *Pulvinulina crassa* and *Pulvinulina tumida*, are comparatively rare, or at all events local in distribution, the

rest are very common. Other *Pulvinulinæ*, occurring abundantly in dredgings from great depths, have never been found in the tow-net gatherings.

By reference to Distribution Table II. the extent and character of the Rhizopod-fauna of Globigerina Ooze will be seen at a glance. The number of species contained in the different samples of bottom-mud included in the Table ranges from twenty to ninety-five. Taking three typical examples, each yielding about fifty species of Foraminifera, the average proportion of pelagic to bottom-species is somewhat less than one to four; but in the proportionate number of specimens the pelagic forms are enormously in excess. Inasmuch therefore as the sea-bottom over a very large portion of the world consists of a deposit of which these pelagic Foraminifera form collectively the chief constituent, everything connected with their manner of life possesses a certain amount of importance.

Wide differences of opinion have existed with respect to the actual relation subsisting between the Foraminiferal fauna of the surface, as represented by the species above enumerated, and that of the sea-bottom;[1] the points admitting of debate, however, have been gradually narrowed, and at the present time appear to lie within very small compass. The chief question concerning which naturalists are not agreed is whether the species referred to are exclusively pelagic, and pass the whole of their existence as free swimming organisms, or whether they have also the power of living, and do live, more or less, at the sea-bottom.

In one of the preliminary papers on Challenger Foraminifera[2] I stated briefly the results of my earlier investigations in connection with this subject, together with the inferences they suggested. During the last three or four years, however, I have had the opportunity of examining much more fully the large collection of surface-gatherings obtained during the Challenger Expedition, as well as important material collected by Mr. Murray on the cruise of the "Knight Errant"; and as there are certain points in which my previous experience has not been entirely confirmed, I may be permitted to make a few remarks, both by way of correction and in order to explain more fully, in some respects, what appears to me to be the present aspect of the question. The observations requiring correction are those relating to the comparative dimensions of the surface- and bottom-specimens of the same species, and the thickness of the shell-wall. In the various batches of surface-organisms which had come under my notice at the time I wrote, not

[1] *See*—Wallich, 1862, The North Atlantic Sea-bed (*Van Voorst*);
Major Owen, 1866, *Journ. Linn. Soc. Lond.*, vol. ix. (Zool.) p. 147;
Wyville Thomson, 1874, *Proc. Roy. Soc.*, vol. xxiii. p. 32;
Carpenter, 1875, *Ibid.*, p. 234;
Wallich, 1876, Deep-sea Researches on the Biology of Globigerina (*Van Voorst*),
as well as numerous other papers and notes, earlier and later, by Ehrenberg, Müller, Bailey, Haeckel, Wallich, Carpenter and Thomson, Jeffreys, Murray, Schacko, &c.

I have endeavoured as far as possible to limit the scope of the present remarks to matters within my own observation, and have made no attempt to summarise the labours of previous writers, still less to pass judgment upon them.

[2] *Quart. Journ. Micr. Soc.*, 1879, vol. xix., N. S., p. 292.

only were the Foraminifera, whether judged by individual specimens or by an average, very definitely smaller than those of the bottom-deposits, but the shells were unmistakably thinner and more delicate. The same has not been the case in many of the mountings I have since examined; and the result of a fresh and somewhat extensive series of comparative measurements has convinced me that (with some reservation as to *Orbulina*) there is no sufficient difference between the surface- and bottom-shells, either as to size or substance, to serve as the foundation of a general argument.

It appears at first sight a very simple matter to determine whether organisms dredged from the sea-bottom have in reality lived there; but this is far from being the case with respect to the microzoa. The bed of the ocean is composed of deposits of unknown thickness, consisting in many places chiefly of Foraminiferal remains which have been accumulating for countless ages. Under any circumstances it is only in the thin superficial film that living specimens are to be found, and even there they are mixed with a large proportion of dead and empty shells. The masses of ooze brought up by means of a heavy dredge or trawl, possibly representing a layer of the sea-bottom several inches thick, are manifestly useless for investigations of this sort unless examined immediately on arriving at the surface, before the different portions have become intermixed; indeed it would be almost as reasonable to expect to find sarcode animals in a Tertiary deposit as in the bulk of the material so obtained. This remark does not apply in the same degree to the samples obtained by the smaller sounding appliances. The old method of taking soundings with the greased lead, though of little utility for the wider purposes of zoological research, was perhaps better adapted for securing a knowledge of the thin superficial layer; and it is quite possible that some of the discrepancies in the accounts given by different observers may be due to the different methods by which their material was collected.

Where a tow-net can be attached to the dredge or trawl, so as to receive amongst other things the organisms thrown up by the rough disturbance of the surface of the bottom-mud, the contents are often of somewhat different character to those of the dredge itself. Not unfrequently a portion of the Foraminiferal shells collected by this means are filled with sarcode; and from such material, after treatment with acid, I have obtained the sarcode-bodies of a number of pelagic species; amongst them, in addition to some of the varieties of *Globigerina*, easily recognised specimens of *Sphæroidina dehiscens* and *Pulvinulina menardii*. It is possible, of course, that these may have been pelagic specimens collected by the net during its passage through the water, but there was nothing in their appearance to suggest that their origin was different from that of the other Foraminifera in the same gatherings; and they have at times presented themselves in numbers far too large, as it appears to me, to be satisfactorily accounted for on that supposition. The sarcode, in all cases, was yellowish-brown and granular, precisely resembling that of in-shore Rhizopods that have in like manner been kept some time in alcohol before being decalcified. The soft, jelly-like lobes

of *Sphæroidina* retained the form of the pseudopodial tubulation of the shell as minute cylindrical projections from the surface. So far as the general fact of the presence of the animal sarcode in bottom-specimens of pelagic forms is concerned, these observations possess no novelty, but are simply confirmatory of the results set forth by many previous writers; indeed, the sarcode-contents of the shells of bottom-*Globigerinæ* were fully and accurately described by Wallich more than twenty years ago.

The distribution of the little northern species, *Globigerina pachyderma*, presents some features of interest bearing upon the matter in hand. This is a strongly marked form, and easily recognised. It is common in the Arctic Seas, generally occurring in company with small specimens of the typical *Globigerina bulloides*. In the Faröe Channel, as is well known, there exist, side by side, two sharply defined areas, of which the bottom temperature differs to the extent of 16° or 17° Fahr., though there is no material difference as to depth, and the temperature of the surface-water is practically uniform over the whole. On the cruise of the "Knight Errant" bottom-specimens of *Globigerina pachyderma* were dredged abundantly in the "cold area," and, more sparingly, at one Station in the "warm area." In the tow-net gatherings *Globigerina bulloides* was equally plentiful over the "cold" and "warm" areas; but neither there, nor hitherto in any other region, has *Globigerina pachyderma* been met with at the surface. It is also worth mentioning that occasional specimens of the latter species have been found in the Red Clay of the abyssal depths of the North Pacific and elsewhere.

In alluding to the comparative thickness of the shells of surface- and bottom-specimens, some reservation was made with respect to the *Orbulinæ*. As commonly taken in the tow-net, the calcareous investment of *Orbulina* is a globe of extreme tenuity and transparency, the exterior of which is usually provided with delicate spines, sometimes of great length, but more often relatively short. This outer test encloses a small, internal, polythalamous, *Globigerina*-like shell, which as a rule is also more or less spinous. Compared with these, bottom-specimens are stoutly built, and very variable amongst themselves in shell-texture and other particulars. Perhaps the most noteworthy structural feature of the latter is the way in which the shell is formed of a number of distinct layers, sometimes four or five separate shelly envelopes, one enclosed within the other, yet without any apparent adhesion of their walls. The majority of bottom-specimens, especially those of large size, contain no internal "Globigerine" shell.[1]

To revert to the pelagic specimens. In a gathering taken with the tow-net sunk to 200 fathoms an *Orbulina* was met with, the shell of which measured nearly $\frac{1}{550}$th inch (·046 mm.) in thickness; this was so exceptional that it attracted instant attention. I have

[1] Since these introductory paragraphs have been in type, I have received from my friend M. Schlumberger a copy of a note "Sur l'Orbulina universa, d'Orb." (dated 21st April 1884), in which the occurrence of specimens with and without the internal *Globigerina*-like shell is brought forward as an example of "dimorphism" (see p. viii.), the single-chambered shell being the homologue of the large initial segment of other Foraminifera. Is it possible that of the "pair," in this instance, one form normally inhabits the surface-water the other the bottom-ooze?

also notes of three surface-specimens in which the shell-wall was partially double, and of one in which it was partially triple. In no case were the additional layers complete, and they were invariably so thin that they could only be described as films; in point of fact they bore no resemblance to the multiple tests of bottom-specimens. This is as far as I can speak from my own knowledge. I have, however, before me a pencil sketch by Mr. George West of a portion of a double-shelled surface-specimen of which the walls are of measurable thickness, being each rather under $\frac{1}{1500}$th inch (·017 mm.), or altogether, including the interspace, about $\frac{1}{750}$th inch (·034 mm.); and therefore, like the single specimen first mentioned, as thick as many bottom shells. But under any circumstances such examples are very exceptional, and the great bulk of the surface *Orbulinæ* that have come under my notice are precisely such as I have endeavoured to describe. It is perhaps needless to pursue this portion of the subject further, inasmuch as the general features of the genus are discussed at some length at a later page.

Taken by themselves, the facts that have been brought forward, as well as some others of less significance that might be adduced, tend to the inference that the Foraminifera which are found living in the open ocean have also the power of supporting life on the surface of the bottom-ooze;[1] and further that, so far as our present knowledge goes, there is at least one variety of *Globigerina* which lives only at the sea-bottom. But this is only one side of the story.

It has been suggested, for example, that the presence of bottom-specimens of *Globigerina pachyderma* in the "cold area" of the Faröe Channel, notwithstanding the entire absence of the species from the surface-gatherings, may be explained by the supposition that the former are exclusively dead shells brought by the cold bottom-current from the far north, and that the species will eventually be found leading a pelagic existence in the Arctic Seas. That is, no doubt, a possible solution of the difficulty; and if it were necessary to believe that all *Globigerinæ* live only at the surface, it might be regarded as sufficient; happily it is one of those points which are pretty sure to be cleared up by future investigation.

Under ordinary circumstances there is a close and very obvious relationship between the pelagic fauna and that of the sea-bottom immediately beneath; and it becomes evident on even a slight examination that the distribution of the constituent species of the former, and therefore to a considerable extent of the latter also, is dependent on the temperature of the surface-water.[2]

[1] There is an observation recorded by Dr. Carpenter in the following paragraph that appears too important to be left entirely unnoticed:—

"Of the existence of living *Globigerinæ* in great numbers in the stratum of water immediately above the bottom, at from 500 to 750 fathoms depth, I am able to speak with great positiveness. It several times happened, during the Third Cruise of the "Porcupine" in 1869, that the water brought up by the water-bottle from immediately above the *Globigerina*-ooze was quite turbid; and this turbidity was found (by filtration) to depend, not upon the suspension of amorphous particles diffused through the water, but upon the presence of multitudes of young *Globigerinæ*, which were retained upon the filter, the water passing through it quite clear."—*Proc. Roy. Soc.*, vol. xxiii. p. 235.

[2] See Murray, *Proc. Roy. Soc. Edin.*, vol. x. p. 508, Note.

That the chambers of the pelagic Foraminifera are more or less filled with sarcode when they reach the bottom is, I believe, generally admitted, indeed it seems impossible to gainsay the direct evidence of the fact obtained by a succession of competent observers. The question that remains therefore is simply whether the animal continues in a vitally active condition, or is only so much dead protoplasm awaiting decomposition. If it be the latter its preservation from rapid decay requires explanation, which may possibly be found, as suggested by Sir Wyville Thomson, in the low temperature of the sea-bottom.

It may be that no uniform rule applies in all cases. Of *Hastigerina* for example, though in some localities as plentiful at the surface as *Globigerina*, a bottom-specimen even approximately complete is rarely met with, and one that could be mistaken for the living organism never; whilst of *Candeina*, with a test equally thin and fragile, the bottom-specimens are for the most part not only perfect but larger and more fully developed than any hitherto collected at the surface. The fragmentary condition of the bottom-specimens of *Hastigerina* may, it is true, be owing to the spinous exterior of the shell, which renders it additionally liable to fracture; and the completeness of those of *Candeina*, on the other hand, to the extreme smoothness of the surface; but it appears to me to require more collateral evidence than we are yet in possession of to make such a theory quite feasible. Again, when we find specimens of allied forms like *Pulvinulina elegans* and *Pulvinulina menardii* side by side in the same bottom-ooze, the shells and shell-contents, so far as can be told, in exactly similar condition and with every appearance of life about them, it is hard to believe that those of the one species were all living when taken, and those of the other all dead.

In the case of the pelagic Foraminifera, the material placed in my hands for examination was only a small fraction of that actually collected by the naturalists of the Expedition; and some of the difficulties which have been dwelt upon did not present themselves in the same way to those who were in the habit of examining the freshly obtained organisms on shipboard. Mr. Murray, for example, attributes a wider distribution, a greater abundance and frequency of occurrence, and a greater variety in size and thickness of shell, to several pelagic species than I have been able to state from my own observations. The Challenger naturalists had also the opportunity which I have not had of comparing the various layers of bottom-mud obtained by means of the Baillie sounding-tube, and in many other ways had advantages which I have not enjoyed. For these reasons, therefore, I desire to avoid the expression of any very positive opinion on the subject. Questions relating to the geographical and bathymetrical distribution of the shells of pelagic Foraminifera are referred to in Prof. Dittmar's Report on the Composition of Ocean Water (Phys. Chem. Chall. Exped., pt. i. p. 221), and their further treatment may well be left for the forthcoming Narrative volumes and for Messrs. Murray and Renard's Report on Deep-Sea Deposits.

The Chemical Composition of the Tests of Foraminifera.—Another subject of some interest in connection with the bottom-deposits, as well as from a more purely biological point of view, is the chemical composition of the test in the various groups of Foraminifera. Although several recent schemes of classification are based upon the physical characters of the investment, which in turn depends to a great degree upon its chemical constituents, the question is one which has hitherto attracted but little attention. It has been commonly assumed that the tests of the so-called "calcareous" species, whether perforate or imperforate, are composed of carbonate of lime; whilst those of the "arenaceous" forms are constructed of siliceous sand incorporated by means of a calcareous or sometimes slightly ferruginous cement; but though this is true in a broad and general sense, it requires modification in many particulars before it can be accepted as a full or accurate expression of the facts.

The chief difficulties in the way of acquiring reliable information on such points are, firstly, that of obtaining a sufficient quantity of any single species for the purpose of chemical analysis; and, secondly, the amount of care requisite to free the tests both internally and externally from the mud or ooze in which they occur. Amongst the minuter Foraminifera these obstacles are almost insurmountable. Under rare conditions the necessary quantity of shells of the same species, or at any rate of the same genus, may sometimes be secured, but it has been found in practice almost impossible, by mere washing, to render them sufficiently clean to give trustworthy results. With larger specimens there is less trouble, and the sources of error are fewer; whilst such as are of a size to be handled individually without the aid of a microscope require comparatively little special treatment.

The analyses which I am now enabled to quote have, with two or three exceptions, been made by my friends Dr. C. R. A. Wright, F.R.S., of London, and Mr. J. T. Dunn, M.Sc., of Newcastle-on-Tyne; and I may be allowed again to acknowledge the valuable assistance which I have received from these gentlemen in connection with the various chemical questions that have arisen in the course of the present work.

In dealing with the composition of the test, it will be convenient to take the different groups of Foraminifera consecutively, beginning with the Miliolidæ. Concerning the sub-family *Miliolininæ* there is not a great deal to be said. From a sample of the so-called "*Biloculina*-ooze," kindly supplied by Prof. G. O. Sars, an adequate number of shells of *Biloculina ringens* were obtained, which were carefully washed and submitted to analysis. Some doubt, however, was cast upon the result on account of the large proportion of silica which it gave, namely, 10·60 per cent.; the supposition being that, notwithstanding the care exercised in cleaning, the specimens still retained a certain amount of adherent ooze. It is not impossible that this may have been so. Nevertheless, in a subsequent correspondence with Mr. L. Schmelck of Christiania, the author of an elaborate report on the chemistry of the deep-sea deposits of the northern

area of the North Atlantic,[1] the subject was mentioned and the supposed source of error pointed out; and since then Mr. Schmelck has been good enough to forward me a memorandum of an independent analysis of *Biloculina*, made by himself, which is as follows:—

Carbonate of lime,	92·05
Insoluble in hydrochloric acid,	7·61
	99·66

The difference between the various genera of *Miliolininæ* is purely morphological, and, chemically speaking, whatever is true of one is pretty sure to apply in a greater or less degree to all. It is therefore interesting to remember in connection with the presence of silica in *Biloculina*, that at certain Stations in the abyssal area of the North Pacific and elsewhere, manifestly unfavourable to the existence of calcareous organisms, *Miliolininæ* are occasionally found, the tests of which are scarcely affected by acids, the normal calcareous shell being partially or sometimes wholly replaced by a thin, translucent, siliceous investment.

It is well known of course that some few species of *Miliolina* are normally encrusted with siliceous sand; but the porcellanous forms to which reference has been made are such as have white calcareous shells with polished exterior, and thin sections of the test exhibit a perfectly homogeneous texture.

Orbitolites complanata, var. *laciniata*.

	I.	II.	III.	IV.
Silica,	0·58	0·3	0·14	0·11
Carbonate of lime,	86·46	88·2	88·74	87·91
Carbonate of magnesia,	12·52	8·8	9·55	10·50
Alumina, with phosphates of lime and magnesia,	...	2·7	...	...
Alumina and ferric oxide,	0·68	...	...	...
	100·24	100·0	98·43	98·52

Of the more complex *Porcellanea* the genus *Orbitolites* has naturally been selected for chemical examination, not only on account of the size of the specimens, but because of the abundance and importance of the type as a constituent of the coral-reef fauna. The separate analyses of two specimens of *Orbitolites complanata*, var. *laciniata*, gave the somewhat different results recorded in Columns I. and II. of the preceding table. A number

[1] Norwegian North Atlantic Expedition, 1876–1878. Chemistry.—II. On Oceanic Deposits, by Ludwig Schmelck. *Christiania*, 1882.

of shells were therefore operated upon together, so as to yield an average sample; and No. III. represents the composition of a portion of this, from which the salts soluble in boiling water had been removed; whilst No. IV. is that of a second portion of the same without preliminary washing.[1]

The large percentage of carbonate of magnesia indicated by the foregoing figures is a matter of some significance, though it may be easily accounted for by the proportion of magnesium salts existing in sea-water. Happening to have in my possession a sample of a Tertiary deposit described by Karrer and Sinzow (see p. 133) consisting almost exclusively of the shells of one of the simpler types of porcellanous Foraminifera, *Nubecularia*, it appeared worth while, notwithstanding their fossil condition, to ascertain their composition. Clean specimens free from any adherent matrix were selected, and their analysis gave the following result.

Nubecularia novorossica. (Fossil.)

Silica,	0·5
Ferric oxide,	0·2
Alumina, with phosphates of lime and magnesia,	0·9
Carbonate of lime,	72·4
Carbonate of magnesia,	26·0
	100·0

How far these proportions may correspond with those which existed in the living shell it is of course impossible to say.

The peculiar texture to which we apply the term "porcellanous" is an invariable feature of the Miliolidæ, and the shells of the larger group of calcareous Foraminifera (*Hyalina*) present no structure in the least degree similar. The peculiarity may be due to physical conditions attendant on the mode in which the shell-substance is deposited; but, on the other hand, it may be dependent on chemical composition, perhaps on the presence of a certain amount of secreted silica. This has been suggested as a possible explanation by a number of observations which need not just now be dwelt upon. The uniformity of the porcellanous shell-texture as a characteristic of the entire series, notwithstanding some known differences in composition, is, so far as it goes, somewhat against a chemical theory; but the subject is one which is worthy of further investigation.

We may now pass to the Astrorhizidæ and Lituolidæ, two Families in which the test is constructed to a greater or less degree of foreign bodies. In some genera of Astrorhizidæ the investment consists of a chitinous envelope protected by a compact layer of mud of nearly uniform thickness; in others the organic envelope has grains of sand more or less embedded in its substance, the test still retaining its flexibility notwithstanding its arenaceous incrustation; but in the larger portion of the Family, as well

[1] The analyses III. and IV. were made by Dr. J. Gibson, of Edinburgh University, for Mr. Murray.

as in all the LITUOLIDÆ, the walls are built up of foreign particles, siliceous or other, combined by means of an inorganic cement so as to produce a strong and often highly finished test. Although a considerable amount of selective power is frequently manifested, the nature of the extraneous materials is necessarily more or less determined by the character of the sea-bottom. Siliceous sand forms by far the most commonly employed building material, and sponge-spicules, either entire or in fragments, are also frequently used; but whilst a general preference is shown for siliceous particles, no uniform rule prevails, and the same species may be found in one locality building its test of siliceous sand, in a second of coral fragments, and in a third of dead *Globigerina*-shells.

From a chemical point of view, the chief questions of interest attaching to these arenaceous forms are those referring to the secreted inorganic matter or shell-substance, which serves to incorporate the extraneous particles of which the test is mainly constructed. The amount of inorganic "mortar" or "cement" varies exceedingly, not only in different species, but in individuals of the same species from different localities.

In *Rhizammina*, which takes the form of long, flexible, branching tubes, the mineral particles appear to be attached to the organic envelope without the assistance of any secreted inorganic matter.

Rhabdammina abyssorum, the test of which consists of rigid tubular arms radiating from a centre, furnishes an example of variability both as to chemical and physical characters. The following analyses are from examples obtained from different and widely separated localities. No. I. refers to specimens of light reddish-brown hue and rough exterior, dredged in the North Atlantic; No. II. to specimens of very dark colour, and comparatively smooth exterior (owing to the presence of a much larger proportion of cementing material) dredged in the Pacific, just south of the equator, between Papua and the Admiralty Islands.

Rhabdammina abyssorum.

	I.	II.
Silica, ...	94·7	88·26
Ferric oxide, ...	2·4	7·41*
Carbonate of lime, ...	2·9	4·01
	100·0	99·68

* Including a small quantity of alumina not separately estimated.

The closely related genus *Hyperammina* displays as great or perhaps even greater diversity in the texture and superficial characters of the test, and a corresponding variability as to the relative proportions of extraneous and secreted constituents. The chemical examination of *Hyperammina friabilis*, a large species with thick walls composed of loosely aggregated sand, gave results differing but little from those yielded by the rougher specimens of *Rhabdammina*, above quoted.

Hyperammina friabilis.

Silica,	93·63
Ferric oxide,	2·02
Carbonate of lime,	3·95
	99·60

On the other hand, some of the smaller specimens of *Hyperammina elongata* have finely cemented tests, resembling *Trochammina* in their compact texture and smooth or sometimes polished exterior.

Fragments of the gigantic *Syringammina* were found on analyses to contain more than 35 per cent. of carbonate of lime, notwithstanding the loose friable consistence of the test. Further examination, however, showed that this was due to the presence of large numbers of the minuter Foraminifera amongst the sand of which it was built, and not in any great degree to secreted calcareous matter.

The chemical features of the LITUOLIDÆ have only been investigated so far as concerns two species, *Haplophragmium latidorsatum*[1] and *Cyclammina cancellata*, the analyses of which gave the following figures :—

	Haplophragmium latidorsatum.	*Cyclammina cancellata.*
Silica,	76·1	84·8
Ferric oxide, with a little alumina,	16·3	9·4
Carbonate of lime,	7·3	5·5
	99·7	99·7

The proportion of alumina in both cases was too small to be worth separate estimation, and was probably due to traces of adherent foreign matter.

From these determinations it is evident that, in a considerable section of the arenaceous genera, whether ASTRORHIZIDÆ or LITUOLIDÆ, the substance secreted by the animal for the incorporation of foreign bodies in the construction of the test, is composed of ferric oxide and carbonate of lime in variable proportions, the former being often in considerable excess. There are some cases, however, for example the large specimens of *Reophax nodulosa* described at page 294, in which after careful treatment with acids, under conditions to ensure the complete removal of ferruginous and calcareous constituents, the test is not disintegrated but retains its form, the sand-grains of which it is built still cohering with sufficient firmness to admit of the specimen being freely handled. Seeing that this occurs in dead and empty tests, it can scarcely be attributed to any remaining organic matter, so that it is probably due to the presence of small quantities of silica, free or combined, as an element of the cement. The fact that there are a few species which, in the absence of siliceous material, form their tests of calcareous sand,

[1] The *Lituola subglobosa* of M. Sars.

has been already adverted to. Shells so constructed are generally characterised by their thick walls and relatively large proportion of cement, the cement itself consisting almost entirely of carbonate of lime.

Little remains to be said concerning the GLOBIGERINIDÆ, LAGENIDÆ, and ROTALIDÆ, as they belong for the most part to the category of the minuter forms, of which it is almost impossible to obtain samples sufficiently pure and clean for satisfactory analysis. Mr. Murray, however, reports that a considerable bulk of pelagic *Globigerinæ*, collected by means of the tow-net, were dissolved by hydrochloric acid, leaving no residue whatever.

Less difficulty is experienced with respect to the NUMMULINIDÆ, inasmuch as many of the species are plentiful and the individual shells of comparatively large size. Analyses are appended of *Amphistegina lessonii* and *Operculina complanata*, two good representative types. The specimens of the former were procured from the Cape de Verde Islands, those of the latter from near Amboyna.

	Amphistegina lessonii.	*Operculina complanata.*
Silica, ...	0·30	0·2
Ferric oxide, ...	trace	0·1
Alumina, with phosphates of lime and magnesia, .	1·95	1·3
Carbonate of magnesia, ...	4·90	4·8
Carbonate of lime, with a little organic matter, .	92·85	93·6
	100·0	100·0

Practically, therefore, these forms may be said to consist of carbonate of lime with about 5 per cent. of carbonate of magnesia.

BIBLIOGRAPHY.

THE following is a catalogue of books and papers referring to the Foraminifera, arranged as nearly as possible according to date of publication. It was compiled for reference during the progress of the present Report, but as no general synopsis of the literature of the Foraminifera, of even approximate completeness, has been published since that of Prof. W. C. Williamson in 1858, it has been thought that it might be of like service to others working on the subject.

To keep the list within reasonable dimensions it has been found needful to restrict it to papers bearing directly, in one way or other, upon the Reticularia, and except in a few instances where special reasons to the contrary exist, those relating exclusively to the Lobose and Radiolarian groups of Rhizopoda are omitted; and for the same reason it has not been thought requisite to include the title of every geological treatise in which the mere occurrence of a Nummulitic rock or a Fusulina-limestone happens to be recorded. On the other hand, a few titles have been admitted of memoirs which relate to organisms of still unsettled zoological position, which, from similarity of structure, have either been classed by authors with the Foraminifera, or have been made the basis of closely allied groups. With some exceptions, reviews, abstracts, and reprints are omitted, as are also some of the less important contributions to the *Eozoön* controversy. Comparatively few works of the præ-Linnean era are named, as these for the most part have but little bearing on the practical study of the Foraminifera, even in relation to nomenclature. The reader interested in the very early literature of the subject will find abundant references in the "Saggio storico" of Michelotti, in the footnotes of MM. d'Archiac and Haime's classical memoir on Nummulites (pp. 8–23), and in the introductory chapters of Dr. Philippe de la Harpe's projected, but alas! unfinished, monograph of the same group.

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Page 2, 10th line from top. The following is an amended reference:—

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Page 20. The marginal date 1864 should be at line 14, instead of line 25.

Page 25, 2nd line from bottom. "Fontannes, F., Première Note, &c." Accidentally misplaced, the date of publication being 1880.

Page 33. Lines 18 and 19 transposed.

APPENDIX.

Additional titles of memoirs and notices concerning the Foraminifera.[1]

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[1] Since the foregoing sheets were printed I have had the opportunity of comparing them with the proof-sheets of general zoological bibliography in course of preparation by Mr. D'Arcy W. Thompson of Cambridge, to which work I am indebted for several of the titles which appear in this Appendix.

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CLASSIFICATION.

The simplest beings which are recognised as belonging to the Animal Kingdom, that is to say, all below the CŒLENTERATA in point of organisation, are by general consent placed together to form the Sub-kingdom PROTOZOA. They possess one character in common, namely, that the body consists of jelly-like protoplasm or sarcode, which, so far as can be ascertained, is either structureless or only specialised in a comparatively rudimentary way. In many of the constituent groups, the skeleton or framework of the animal takes beautifully symmetrical and often complex forms, whilst the sarcode body retains its simplicity, and produces no organ more highly specialised than the nuclei and contractile vacuoles, which may or may not be present in the jelly-like mass.

The Sub-kingdom PROTOZOA is variously treated by different systematists, but the division into three classes,—*Monera*, *Rhizopoda*, and *Infusoria*, commends itself as a good working arrangement. Whether the *Spongida* are more nearly related to the PROTOZOA or the CŒLENTERATA is a question which need not be considered here.

Classification of the Rhizopoda.

The discovery of the true nature of sarcode organisms is due to the French naturalist Dujardin, by whom they were originally described under the collective name *Symplectomères*[1]. In subsequent papers by the same author, preference was given to the term *Rhizopodes*, and this, in its latinised form, has since been almost universally adopted.

Dujardin's earlier researches were published in the year 1835, and the number of forms then recognised as belonging to the group was exceedingly small; but before the appearance of his memoir on the Natural History of Zoophytes,[2] in 1841, the list had been considerably increased; and, in the classification proposed in that work, the Rhizopoda constitute an independent Family of the Infusoria, which, without intermediate grouping, is divided into eight genera, namely:—

1. *Arcella.*
2. *Difflugia.*
3. *Trinema.*
4. *Euglypha.*
5. *Gromia.*
6. *Miliola.*
7. *Cristellaria.*
8. *Vorticialis.*

The author, however, appears to have been well aware that the knowledge of such organisms was in its infancy, and he mentions several recent types that he had refrained

[1] *Bullet. Soc. Sci. Nat. France*, 1835, No. 3, p. 36.

[2] Histoire Naturelle des Zoophytes.—Infusoires, comprenant la physiologie et la classification de ces animaux, &c., p. 240, Paris, 1841.

from adding to the list only because he had not seen the filiform extensions of the sarcode. He further states his belief that many well-known minute fossils would prove to be true Rhizopods.

But little advance was made on this arrangement until the researches of Claparède and Lachmann, some seventeen years later, and the publication by them of a series of memoirs on the Rhizopoda and allied organisms,[1] embodying a scheme of classification which has served as a groundwork for many subsequent systematists. The Class was grouped by these authors in the following manner :—

Claparède and Lachmann, 1858–9.

Class.	Orders.	Families.
RHIZOPODA, . .	I. Proteina, ...	*Amœbina.*
		Actinophryina.
	II. Echinocystida, ...	*Acanthometrina.*
		Thalassicollina.
		Polycystina.
	III. Gromida, ...	*Gromida.*
	IV. Foraminifera, ...	*Monothalamia.*
		Polythalamia.

The well-known Introduction to the Study of the Foraminifera, which appeared in 1862, contained a preliminary essay on the Rhizopoda in general, as well as a chapter devoted more particularly to the systematic arrangement of the Foraminifera; and since that time the principles of classification laid down by Dr. Carpenter and his colleagues have been accepted and acted upon by students of the Foraminifera in this country, with very little exception. The arrangement of the Rhizopoda which is there proposed,[2] resembles in its more important features that introduced by Claparède and Lachmann, but is even more simple in its details. The nature of the pseudopodia, whether lobose, simple and radiating, or reticulated and anastomosing, forms the basis of the distinction between the three primary divisions. The whole is summarised in the subjoined table:—

Carpenter, 1862.

Class.	Orders.	Families.
RHIZOPODA, . .	I. Lobosa, ...	*Amœbina.*
	II. Radiolaria, ...	*Actinophryna.*
		Acanthometrina.
		Polycystina.
		Thalassicollina.
	III. Reticulosa, ...	*Gromida.*
		Foraminifera.

[1] Études sur les Infusoires et les Rhizopodes, vol. i. p. 434.—Professor Max Schultze's memoir, bearing date four or five years earlier than this, contains a scheme of classification, but as it refers primarily to the Polythalamia I have preferred to notice it later on.

[2] Introd. Foram, p. 17. In subsequent portions of the work, Order III. is written Reticularia; and in the classification of the Reticularia, pp. 62, 149, &c., the term "Family" is applied to the smaller subordinate groups, *Miliolida, Lituolida, Lagenida, &c.*

But few years had elapsed before a fresh method of classification was suggested by Dr. G. C. Wallich,[1] which is of considerable interest, as being founded upon a totally different set of characters. The nature of the pseudopodial extensions of the sarcode is regarded by Dr. Wallich as a matter of secondary importance, and the features selected for the primary division of the Class into Orders are the presence or absence of nuclei and contractile vesicles; whilst the chemical composition and minute structure of the skeleton, and the form of the pseudopodia are only recognised in the subsequent division into minor groups, as shown in the annexed table:—

Wallich, 1865.

Class.	Orders.	
RHIZOPODA, . .	I. Herpnemata, with no definite nucleus and no contractile vesicle.	
	Skeleton never siliceous, . .	*Foraminifera.*
	Skeleton invariably siliceous, .	*Polycystina.*
	II. Protodermata, with definite nucleus but with no contractile vesicle.	
	Skeleton solid, . . .	*Plagiacanthidæ.* *Acanthometrina.* *Thalassicollina.*
	Skeleton tubular, . .	*Dictyochidæ.*
	III. Proteina, with definite nucleus and contractile vesicle.	
	Pseudopodia monomorphous,	*Actinophryna.*
	Pseudopodia polymorphous, .	*Amœbina.*

It would occupy too much space, and without adequate advantage, to follow minutely the progress of research, or even to summarise the views of the various authors who have written upon the systematic arrangement of the Rhizopoda during the last twenty years; the works of Ehrenberg, Max Schultze, Haeckel, F. E. Schulze, Archer, Bütschli, and others will occur to everyone conversant with the literature of the subject, and may be consulted by those interested in its history. The scope of the present Report is limited to a single section out of the many into which the Rhizopoda are now divided, and the more practically useful plan appears to be to introduce in full one of the more recently proposed schemes of Classification, in order to represent in its principal features the condition of our knowledge at the present time. None perhaps is better suited to this purpose than the synopsis appended to Prof. R. Hertwig's admirable treatise on the Radiolaria,[2] of which the following is a translation.

[1] *Quart. Journ. Micr. Sci.*, vol. xiii. p. 82.
[2] Der Organismus der Radiolarien, p. 142.

Classification of the RHIZOPODA, R. Hertwig, 1879.

Cellular organisms which move and nourish themselves by means of changeable extensions of their protoplasmic bodies (pseudopodia).

I. Monera.

Rhizopoda without nucleus; of indefinite changeable form.

1. *Gymnomonera*—Monera without skeleton.
2. *Lepomonera*—Monera with skeleton.

II. Amœbina.

Rhizopoda with one nucleus or more than one; of indefinite changeable form; either without skeleton or with an irregular skeleton.

1. *Gymnamœbæ*—Amœbæ without skeleton.
2. *Lepamœbæ*—Amœbæ with skeleton.

III. Thalamophora.

Rhizopoda with one nucleus or more than one, and a chitinous monaxial shell which is usually calcareous externally, and always possesses one or two openings for the passage of the pseudopodia.

1. *Monothalamia*—Shell single-chambered, not calcareous.
   (a) *Amphistomata*, shell open at both ends.
   (b) *Monostomata*, shell open at one (oral) extremity, closed at the opposite end.
2. *Polythalamia*—Shell calcareous, with an opening at the oral extremity; generally consisting of many chambers, which are arranged one after the other in a straight or a (spiral or irregular) curved row.
   (a) *Imperforata*, shell-wall solid.
   (b) *Perforata* seu *Foraminifera*, shell-wall perforated with numerous small pore-canals.

IV. Heliozoa.

Rhizopoda of globular form, with one nucleus or more; with radiating pseudopodia, pointed and thread-like, issuing from every part of the surface.

1. *Aphrothoraca* seu *Actinophryidæ*—Heliozoa without skeleton.
2. *Chalarothoraca* seu *Acanthocystidæ*—Heliozoa with a skeleton which is formed of distinct pieces.
3. *Desmothoraca* seu *Clathrulinidæ*—Heliozoa with a clathrate or net-like ball.

V. Radiolaria.

Rhizopoda of rounded shape, with one nucleus or more, which united with a part of the sarcode, and enclosed by a membrane, forms the central capsule; with a gelatinous envelope, and with radiating, pointed, thread-like pseudopodia issuing from the surface.

1. *Thalassicollidæ*.
2. *Sphærozoidæ*.
3. *Tripylidæ*.
4. *Peripylidæ*.
5. *Monopylidæ*.
6. *Acanthometridæ*.

Note.—The following additional or alternative arrangements are proposed by Professor Hertwig for sections III. and IV.–V.

Supplementary Table I.

III. THALAMOPHORA.

1. *Imperforata*—Thalamophora with either one- or many-chambered, chitinous or calcareous shells; with one or two apertures, but possessing no pore-canals.
   (a) *Amphistomata.*
   (b) *Monostomata.*
2. *Perforata* seu *Foraminifera*—Thalamophora, usually with many-chambered shells, which besides the general aperture possess numerous pore-canals.

Supplementary Table II.

IV. RADIOLARIA.

Rhizopoda of rounded form, with one nucleus or more; with radiating, pointed, thread-like pseudopodia issuing from the surface.

1. *Heliozoa*—Radiolaria without central capsule.
2. *Cytophora*—Radiolaria with central capsule.

In the foregoing table the Order THALAMOPHORA practically corresponds to the FORAMINIFERA of the other authors; whilst the latter term, possibly under a mistaken impression as to its original application, is confined to those forms which possess calcareous and perforate tests. Exception may also be taken to the subdivision of the Order into *Monothalamia* and *Polythalamia*, a distinction of little or no zoological value; as well as to the employment of the terms *Perforata* and *Imperforata*, which embody characters not uniformly applicable to the groups for which they have been used. These however are minor considerations which do not materially affect the value of the scheme in its wider aspects.

A passing notice may be accorded to the classification adopted by Professor Leidy in his recent elaborate monograph upon the Fresh-water Rhizopods of North America. His treatment of the group, the general features of which are indicated below, commends itself by its extreme simplicity.

LEIDY, 1879.

Class, RHIZOPODA.

Order I. *Protoplasta.*	Order III. *Radiolaria.*
1. Lobosa.	IV. *Foraminifera.*
2. Filosa.	V. *Monera.*
II. *Heliozoa.*	

It only remains to be added that Professor Huxley discards the use of the word Rhizopoda entirely, and dividing the Protozoa into a "lower and a higher group," MONERA and ENDOPLASTICA,[1] distributes the various structural types between the two. Under this arrangement the *Foraminifera* form a section of the MONERA.

[1] Anatomy of the Invertebrated Animals, p. 76, London, 1877. It is explained in a footnote that this division is adopted as a matter of temporary convenience only.

Classification of the Foraminifera.[1]

It has been already stated that the French naturalist Alcide d'Orbigny was the first to collect the genera of Foraminifera into one zoological group. Before his day their external forms had been studied by a long line of eminent observers—by Plancus and Soldani in Italy, Ledermüller and Batsch in Germany, Linnæus in Sweden, Fichtel and Moll in Austria, Walker and Montagu in England, Lamarck, Defrance and Blainville in France, and many others. By the earlier of these writers they were for the most part regarded as minute varieties of the larger animals which their shells most nearly resembled, and were commonly assigned to such genera as *Nautilus* and *Serpula:* by those of later date, who had arrived at a clearer conception of their distinctive characters, they were formed into independent genera, and distributed over a considerable area of the invertebrata. Until they came in turn to be studied in the living condition, their true zoological position remained still to be determined; but meanwhile d'Orbigny did notable service in treating them collectively as a distinct section of the animal kingdom.

In the "Tableau Méthodique," published in 1826, the Cephalopodous Mollusca (Class Céphalopodes) were divided into three Orders, of which the last was devoted to the Foraminifera; and the Order *Foraminifères* was divided into five families, based upon the mode in which the segments were combined to form the polythalamous shell. After the discovery of monothalamous forms like *Orbulina* and *Lagena*, and the recognition of cyclical types such as *Orbitolites*, two new families were constituted for their reception. In the meantime, however, the researches of Dujardin had made known the true nature of the organisation of the Rhizopoda, and had necessitated the removal of the group to a lower position in the zoological scale. Hence in d'Orbigny's later works,[2] the *Foraminifères* constitute the 4th Class of Zoophytes (2nd division, "*Zoophytes globuleux*,"—placed between *Polypiers* and *Infusoires*), and are divided into seven Orders, with characters which may be briefly summarised as follows :—

Order 1. *Monostègues.*—Shell formed of a single chamber.

Order 2. *Cyclostègues.*—Shell discoidal, composed of concentric lines of cells, simple or multiple; never spiral.

Order 3. *Stichostègues.*—Shell formed of chambers joined end to end in a straight or curved line; never spiral.

Order 4. *Helicostègues.*—Shell composed of chambers in a single series, spirally coiled.

Order 5. *Entomostègues.*—Shell composed of chambers arranged in two alternating series and spirally coiled.

[1] In this, as in other sections of the present Report, the material collected for the preliminary Notes on Challenger Foraminifera, published in the *Quarterly Journal of Microscopial Science*, 1879–1880, has been freely utilised.

[2] Cours élémentaire de Paléontologie et de Géologie stratigraphiques, vol. ii. p. 189. Paris, 1852.

Order 6. *Enallostègues.*—Shell composed of chambers arranged alternately on two or three distinct axes, but not on a spiral plan.

Order 7. *Agathistègues.*—Shell composed of chambers wound round a common axis, each forming half the circumference; texture smooth and imperforate.

Whilst there are certain advantages to be derived from a purely artificial arrangement —as, for example, the Linnean classification of plants—it is seldom that such a method can be adopted without violence in one way or other to manifest natural affinities, and the lowest divisions of the animal and vegetable kingdoms are perhaps least of all suited for its introduction. The chief difficulties that beset the student of systematic zoology, when engaged upon these low types of animal life, arise from the wide range of morphological variation he is obliged to admit within the limits assigned to species; and although there is a great difference in different genera as to the degree of persistence in the distinctive characters of their subordinate forms, it may be fairly doubted whether "species," in the sense in which the word is rightly applied to beings of more complex organisation, can be said to exist amongst the lower Protozoa. It is only as we learn to recognise the fact that amongst the Rhizopoda the so-called "species" represent no more than terms of a series of which very frequently every intermediate link can be supplied, that we arrive at any just idea of their relationship. This being so, it is easy to see where the artificial method must inevitably break down; and though the d'Orbignian plan presents a fair attempt to deal with a great mass of facts, collected by its author with infinite labour, it has now ceased to be of service, and has fallen into desuetude. Its defects are too obvious to need comment. Being practically founded on a single set of characters—the arrangement of the segments—it has none of that elasticity which gives to a system of classification the element of permanence, and which can only exist in proportion to the degree in which the grouping is based upon natural affinity as indicated by the structural features collectively.

In the year 1854, Professor Max Schultze published his classical memoir, Ueber den Organismus der Polythalamien (Foraminiferen), and with it an exposition of his views on the classification of the group. His conclusions, summarised in a convenient table near the end of the volume, are briefly as follows. The Rhizopoda are divided primarily into two sections, NUDA and TESTACEA; the former with the genus *Amœba* for its type, including all naked forms, the latter embracing all the species having an external shell or other investment. The TESTACEA are divided into two Sub-orders—*Monothalamia* and *Polythalamia*—the one subdivided into three Families, the other into seven; and the principal genera, perhaps all that were then known, are distributed amongst them. Schultze's scheme is characterised by a somewhat wider grasp of the subject than its predecessor; but with our present knowledge there is little to be said in favour of an arrangement that places *Orbulina* and *Lagena* in one of its two primary divisions, and *Globigerina* and *Nodosaria* in the other; or wherein *Nodosaria* and *Cristellaria* are

to be found in different Families. There was, in fact, no practical advantage to be derived from its adoption; and though the names of some of the subordinate groups are occasionally employed, it has not, so far as I am aware, been accepted as a whole by any subsequent writer.

In the years 1861–2, practically simultaneously, appeared the memoirs containing the outlines of the two systems of classification which have been adopted, one or other of them, by the present generation of Rhizopodists. That Professor von Reuss,[1] from researches conducted almost exclusively upon fossil specimens, and Dr. Carpenter with Professors Parker and Rupert Jones,[2] from the broader lines of the comparative study of living and fossil types, should have arrived independently at conclusions identical in their more important particulars, affords satisfactory assurance, so far as it goes, that the results in either case have some foundation in natural laws. As these memoirs remain the standpoint from which the discussion of the subject must be commenced, it will be convenient at the outset to state the general features of the schemes they embody, and by comparison, side by side, to show how far they agree in their details, and wherein they differ.

The primary divisions are based upon the minute structure of the shelly skeleton—a ground of distinction hardly recognised by previous authors. In both systems the Foraminifera are divided into two Sub-orders, one of which comprises those forms which have non-porous or imperforate tests, the other those with porous or perforate investment.

The former of these two Sub-orders (*Imperforata*) is in both cases subdivided into two sections, one including the types which have composite tests, that is, built up of sand-grains or similar extraneous bodies more or less embedded in inorganic cement, the other those with calcareous shells of homogeneous porcellanous texture.

In the division comprising the perforate or porous-shelled forms the agreement is less complete than amongst the *Imperforata*, owing to the larger number of types to be accommodated and their greater diversity of structure; nevertheless the arrangement has still to some extent a common basis.

The general relationship of the two schemes will be readily understood by the following comparative table:—

Von Reuss, 1861.	Carpenter, Parker, and Jones, 1862.
A. Foraminifera with non-porous tests	Sub-order—**Imperforata.**
A. With arenaceous tests.	Family—Gromida.
1. *Lituolidea.*	Family—Lituolida.
2. *Uvellidea.*	

[1] Entwurf einer systematischen Zusammenstellung der Foraminiferen, *Sitzungsb. d. k. Ak. Wiss. Wien.*, vol. xliv. p. 355. (The volume for the year 1861, probably not actually issued till 1862.)

[2] Introduction to the Study of the Foraminifera, London, 1862.

B. With compact, porcellanous, calcareous shells. 1. *Squamulinidea.* 2. *Miliolidea.* 3. *Peneroplidea.* 4. *Orbitulitidea.*	Family—Miliolida.
B. Foraminifera with porous shells.	Sub-order—**Perforata.**
A. With glassy, finely porous, calcareous shells. 1. *Spirillinidea.* 2. *Ovulitidea.* 3. *Rhabdoidea.* 4. *Cristellaridea.* 5. *Polymorphinidea.* 6. *Cryptostegia.* 7. *Textilaridea.* 8. *Cassidulinidea.*	Family—Lagenida.
B. With exceedingly porous, calcareous shells. 1. *Rotalidea.*	Family—Globigerinida.
C. With calcareous shells, traversed by a ramified canal system. 1. *Polystomellidea.* 2. *Nummulitidea.*	Family—Nummulinida.

Von Reuss's classification, above quoted, is taken from the "Postscript" to the memoir referred to, in which the primary division into "Foraminifera Monomera" and "Foraminifera Polymera," adopted in the body of the paper, is abandoned. His family *Gromidea* also, which appeared in the original draft and corresponded with the Gromida of the English observers, is omitted entirely in the revised scheme. In the correlation of the two classifications, the principal discrepancy occurs in the Sub-order **Perforata.** The Lagenida and Globigerinida together are almost exactly coextensive with von Reuss's two sections **B,** *A* and *B;* but the (1) *Spirillinidea,* (2) *Ovulitidea,* (7) *Textilaridea,* and (8) *Cassidulinidea,* together with one or two genera from other groups, find place amongst the Globigerinida of the British classification, and the family Lagenida is correspondingly reduced in extent. The family Nummulinida corresponds exactly with von Reuss's section **B,** *C.*

In his latest memoir[1] the same author again somewhat modified his arrangement, making three primary groups of equal zoological value, and reversing the order originally adopted, thus—**A. Kalkschalige Foraminiferen, B. Porenlose Foraminiferen C. Kieselschalige Foraminiferen;** but its general features were left otherwise unchanged.

[1] Das Elbthalgebirge in Sachsen, 2ter Theil, 1874.

It will be seen at a glance that the Families of the German arrangement are much smaller and more numerous than those adopted by the English naturalists; this, however, is subsequently counterbalanced by the more comprehensive "generic types" of the latter. The essential difference, not only between the two systems of classification, but in the entire methods of study and nomenclature, is to be found in the different values of their respective Genera and Species.

Before entering upon any extended criticism, it may be well to introduce briefly certain other plans for the systematic arrangement of the Foraminifera, which have appeared more recently, and which differ in many noteworthy respects from either of the foregoing. Precedence must be given to the synopses published almost simultaneously by Professor T. Rupert Jones [1] and Professor Carl Zittel [2] respectively, the general features of which will, as in the former case, be best understood from collateral tabular summaries.

Rupert Jones, 1876.	Zittel, 1876.
Sub-order I. **Imperforata vel Porcellana.**	Sub-order I. **Imperforata.**
Family I. Nubeculariда.	Family I. Gromidæ.
II. Miliolida.	II. Cornuspiridæ.
III. Peneroplida.	III. Miliolidæ.
IV. Orbiculinida.	IV. Dactyloporidæ.
V. Dactyloporida.	
Sub-order II. **Arenacea.**	
Family I. Parkeriada.	
II. Lituolida.	
Sub-order III. **Perforata vel Hyalina.**	Sub-order II. **Perforata.**
Family I. Lagenida.	Family I. Lagenidæ.
II. Polymorphinida.	II. Globigerinidæ.
III. Buliminida.	(1) *Globigerinæ.*
IV. Textularida.	(2) *Textularinæ.*
V. Globigerinida.	(3) *Rotalinæ.*
(1) *Globigerinina.*	III. Nummulinidæ.
(2) *Rotalina.*	
(3) *Polystomellina.*	
(4) *Nummulinina.*	

Two other outlines of classification, more carefully elaborated than any which preceded them, remain to be noticed, namely those of Dr. Schwager [3] and Pro-

[1] *Monthly Micr. Journ.* No. 86, Feb. 1876, pp. 89–92.

[2] Handbuch der Paläontologie, vol. i. pt. 1, 1876, pp. 61–106.

[3] Saggio di una Classificazione dei Foraminiferi, avuto riguardo alle loro famiglie naturali, per Corrado Schwager. *Bollet. r. Com. Geologico*, 1876–1877.

fessor Bütschli.[1] In both of these something more is attempted than the mere subdivision of the Foraminifera into Families and Sub-families. The distinctive characters of the constituent genera are recorded with sufficient minuteness to be of service to the working naturalist, and the result is in either case a tolerably complete synopsis of the group. The mode of treatment adopted by the two authors is, however, strikingly different. The long experience of Dr. Schwager, gained chiefly by the study of fossil types, has prompted a somewhat artificial method of dealing with the subject; whilst Prof. Bütschli, from a wide general knowledge of the Protozoa, rather than a special or practical acquaintance with the testaceous Rhizopoda, has arrived at conclusions at variance in many essential points from those entertained by any previous systematist. It is nevertheless always of interest to the specialist to compare his results with those dictated by the study of larger groups; and for this reason, if for no other, the latter work has a claim on our attention.

It would occupy too much space to reproduce either of these classifications in full, and summaries similar to those which have been already given will serve for purposes of comparison better than more extended tables.

Schwager, 1877.

I. Foraminifera with purely calcareous perforated tests.
II. Foraminifera with agglutinated tests.
III. Foraminifera with purely calcareous imperforate tests.
IV. Foraminifera with chitinous tests.

I. Foraminifera with purely calcareous perforate tests.

A. Chambers disposed in a single line and on one plane.

1. *Lagenoidea.*
2. *Rhabdoidea.*
3. *Dentalinoidea.*
   (a) Dentalinidæ.
   (b) Pullenidæ.
   (c) Nummulitidæ.
4. *Cristellaroidea.*

B. Chambers disposed in a single line and in a spire (*Turbinoidea*, Schultze).

5. *Polymorphinidea.*
6. *Buliminidea.*
   (a) Buliminidæ.
   (b) Rotalidæ.
7. *Globigerinidea.*
   (a) Globigerinidæ.
   (b) Planorbulinidæ.

[1] In Bronn's Klassen und Ordnungen des Thier-Reichs, 1880, vol. i. (Protozoa) p. 172 *et seq.*

C. With two or more rows of chambers.
8. *Textilaridea.*
(a) Textilaridæ.
(b) Cryptostegia.

D. Concameration more or less complex.
9. *Tinoporidea.*

II. Agglutinated Foraminifera.

A. Constructed in a single line.
1. *Trochamminidea.*
2. *Lituolidea.*
3. *Ataxophragmidea.*

B. With two or more rows of chambers.
4. *Plecanioidea.*

III. Calcareous Foraminifera with imperforate tests.

A. Chambers either disposed in a single continuous series or cyclically.
1. *Cornuspiridea.*
2. *Peneroplidea.*

B. Chambers disposed in more series than one.
3. *Miliolidea.*

C. Shells with complex structure.
4. *Dactyloporidea.*
5. *Receptaculitidea.*

IV. Foraminifera with chitinous tests.
1. *Gromidea.*

The "Uebersicht" of Dr. Bütschli deals with the entire Order, Rhizopoda, first dividing it, as in Max Schultze's scheme, into two Sub-orders, **Amœbæa** (*Nuda*, Schultze) and **Testacea**. The former of these is again divided into two Families, *Amœbæa lobosa* and *Amœbæa reticulosa*, to one or other of which the whole of the naked types are assigned. The arrangement of the **Testacea** is as follows :—

Bütschli, 1880.

RHIZOPODA, { Sub-order I. AMŒBÆA, Ehrenberg. / Sub-order II. TESTACEA, Schultze.

Sub-order—TESTACEA, M. Schultze. (*Thalamophora*, R. Hertwig.) Including all testaceous Rhizopods, whatever the structure of the test.

A. Tribe.—Imperforata, Carpenter.

Family 1. *Arcellina*, Ehrenberg.
2. *Euglyphina*, Bütschli.
3. *Gromiina*, Bütschli.
4. *Amphistomina*, Bütschli.
5. *Miliolidina* (*Miliolidea*, Reuss, + pars Lituolidarum).
6. *Peneroplidina*, Reuss.
7. *Orbitolitina* (*Orbitulitidea*, Reuss).
8. *Arenacea*, Bütschli.

B. Tribe.—Perforata, Carpenter (+ pars Lituolidarum).

Family 1. *Rhabdoina*, Schultze.
2. *Polymorphinina*, Bütschli.
3. *Globigerininæ*, Carpenter (p.p.).
Sub-family (a) Globigerinæ, Carp.
(b) Cryptostegia, Reuss.
(c) Textularidæ, Carp.
(d) Rotalinæ, Carp.
4. *Nummulitinæ* (*Nummulinida*, Carpenter) emend. Bütschli.
Sub-family (a) Involutinæ, Bütschli.
(b) Pulleninæ, Bütschli.
(c) Nummulitidæ.
(d) Fusulinidæ, Möller.
(e) Cycloclypidæ, Bütschli.

These tables taken collectively form a sort of epitome of the literature of the last twenty years affecting the classification of the Foraminifera. The publication of Max Schultze's classical memoir, though its least successful portion was that devoted to the systematic arrangement of the animals whose life-history the author had so carefully investigated, paved the way for a natural method of grouping; and not many years elapsed before it was followed by the "Entwurf" of Professor Reuss, and the more elaborate "Introduction" of Messrs Carpenter, Parker, and Jones.

The classification proposed by Reuss was excellently adapted to meet the wants of the working palæontologist, and it obtained very general acceptance on the continent of Europe; but apart from the deficiencies arising from the discovery of many new types, and the abandonment of others since shown to have been wrongly placed amongst the Rhizopoda, it has serious defects which cannot be overlooked.

The primary division of Foraminifera into *Perforata* and *Imperforata* would be very convenient if it could be employed in its original sense; but it is now a well recognised fact that some of the arenaceous types have interstitial openings amongst the sand-grains of which the test is built, as well as a general aperture; that others, like *Psammosphæra* and *Sorosphæra*, have no general aperture, but only interstitial orifices; and that a few, *Thurammina* for example, have numerous small mammillate orifices, irregularly disposed over the surface of the test, either with or without a general aperture. If the arenaceous group be removed from the *Imperforata*, there remain but the chitinous and porcellanous forms. That the *Porcellanea* are, under all circumstances, imperforate, scarcely admits of question, and that a large proportion of the *Arenacea* share the same condition, there is no reason to doubt; but the exceptions in the latter case are so numerous and varied, that the *Arenacea* cannot be included, as a whole, in a Sub-order of which the distinctive character is the imperforate test, and if omitted the term becomes at once

misleading; therefore it is manifestly better to abandon an initial subdivision based solely on the condition of the investment with respect to perforation.

The adoption of three Sub-orders, instead of two, depending on shell-texture rather than on mere perforation, as latterly proposed by Reuss, meets the difficulty in part, but is still open to objection. On the one hand, there is a considerable group of true *Miliolæ*, our knowledge of which is much extended by the Challenger collections, that have rough arenaceous tests; and on the other, the large and important family TEXTULARIDÆ is practically unprovided for, inasmuch as it is sometimes truly arenaceous, sometimes hyaline and perforate, and sometimes externally sandy but with an inner perforate shell. The author endeavours to meet this difficulty by dividing certain genera and placing the two halves in different Sub-orders; thus *Textularia* appears as *Textularia* amongst the hyaline forms and as *Plecanium* amongst the arenaceous, and *Bulimina* in the same way as *Bulimina* and *Ataxophragmium;* but this is cutting the knot rather than untying it, and even were so summary a method practically convenient, the proposal to split a natural group like that comprising the Textularian and Bulimine types in order to meet the exigencies of an artificial distinction, is not one to be lightly adopted.

Passing from Sub-orders to Families, even greater anomalies are apparent, especially amongst the hyaline forms. For example, *Spirillina* is found at almost the opposite end of the scale to the Rotaline genera; *Nodosaria*, *Cristellaria* and *Polymorphina* are placed in three different Families, whereas, in point of fact, they are connected by intermediate and dimorphous modifications, so as to form an absolutely continuous series; and *Textularia*, *Bulimina* and *Cassidulina* are similarly separated. These appear to me fatal objections to the details of the classification, viewed as a natural arrangement.

What has been already urged against the employment of the terms *Perforata* and *Imperforata* in Reuss's scheme, applies with equal force to that of Dr. Carpenter and his colleagues. There is, however, in the English arrangement but little infringement of natural relationship in the constitution of the Families, except, perhaps, the association of *Textularia* and its immediate allies with *Globigerina* and the Rotaline genera. Apart from this, its chief drawback is that the divisions are too large to be zoologically convenient, a defect more and more felt as the number of known genera is augmented.

Rupert Jones, in his outline, entirely omits the forms having chitinous tests (*Gromida*), and, following Reuss's example, divides the Foraminifera into three Sub-orders, namely, PORCELLANA, ARENACEA, and HYALINA. He employs the term *Imperforata* as a synonym for *Porcellana*, that is to say, for a section exactly coextensive with Carpenter's family *Miliolida;* whilst *Perforata* is given as an alternative for *Hyalina*. In other respects the general plan differs from that of the "Introduction," chiefly in the redivision of the Sub-orders into a larger number of Families.

Turning now to the synopsis in Professor Zittel's Handbook of Palæontology, we

find the primary division of the Foraminifera into the *Imperforata* and *Perforata* still retained. His Sub-order *Imperforata* comprises all the chitinous and porcellanous genera, whilst the Sub-order *Perforata* is subdivided into the three Families of Carpenter's classification. The distinctive feature of Zittel's scheme is that the arenaceous forms have no independent position, but are distributed amongst the *Porcellanea*—part of them being assigned to the Family *Cornuspiridæ*, the remainder to the *Miliolidæ*. Such an arrangement does not commend itself, in view of the perforate tests of many of the sandy types; and the appearance side by side, in the same Family, of genera as widely different as *Botellina* and *Orbitolites*, or as *Nubecularia* and *Trochammina* suggests some of the anomalies which it entails.

The method of classification proposed by Dr. Schwager would leave little to be desired were the sole aim of the systematist the easy determination of the genera of doubtful specimens. An artificial system, indeed, has advantages over any other in this respect, and it would not be easy to construct a more orderly or more complete synopsis than the one furnished in Dr. Schwager's modest paper. But, as has been before observed, the precision of definition suited to the comparatively stable characters of more highly organised animals can seldom be employed in the treatment of forms as variable as the Rhizopoda; and in addition to their extreme variability, a further difficulty presents itself in the tendency to isomorphism amongst very distinct types. Thus it happens that in any artificial arrangement of the Foraminifera, closely allied genera are often widely separated, whilst others with no immediate affinity are thrown into juxtaposition. One or two examples from Schwager's synopsis will serve to illustrate this point. We need not go beyond the first section, comprising "calcareous, perforate Foraminifera, with segments disposed in one line and in one plane," in which we find *Nodosaria*, *Dentalina* and *Vaginulina*, in three distinct Families, whilst *Polymorphina* and *Uvigerina* are removed to quite another division of the table. Now, in point of fact, the connection between *Nodosaria* and *Dentalina* is so close, that it is not too much to say that many species are sometimes Nodosarian and sometimes Dentaline; and the difference between some varieties of *Vaginulina* and *Dentalina* amounts to little more than a slight lateral compression of the shell. Of the position of *Polymorphina* and *Uvigerina* in the same series I shall have to speak on a future page. So much for the separation of allied types. On the other hand, we find genera as diverse as *Dentalina*, *Pullenia*, *Polystomella* and *Nummulites* all placed in the same Family;—or to state the point somewhat differently, *Dentalina* is in nearer relationship with *Polystomella* than with *Nodosaria*; and genera like *Fusulina*, *Amphistegina* and *Heterostegina*, come between *Dentalina* and *Vaginulina*. Similar anomalies, though perhaps few so striking as these, are to be met with in other sections of the table. In such cases natural affinity is sacrificed to the exigencies of a system—a heavy price to pay for its comparatively trifling advantages.

Professor Bütschli's synopsis of the Rhizopoda covers too large an area to invite

general or extended criticism. The Sub-order TESTACEA, which comprises all testaceous Rhizopods, whatever the nature of their investment, is divided into two Tribes—*Imperforata* and *Perforata*. The former of these terms is employed in a much wider sense than in any previous classification, and is made to include (1) all Rhizopods with chitinous tests, whether the pseudopodia are lobose or reticulated; (2) the *Porcellanea;* and (3) a portion of the *Arenacea*. To the *Lituolidæ* no distinct position is assigned, but part of them are placed with the hyaline forms they most nearly resemble in shape (usually inserted as "allied genera"), and the rest are similarly annexed to porcellanous Families such as *Peneroplidina*. Turning to the *Perforata*, there is little to notice in the arrangement of the earlier groups, which is more or less in accordance with Dr. Carpenter's plan; but the Family *Nummulitinæ* is made more than usually comprehensive, and the genera are associated in the following manner:—(a.) *Involutina*, *Archædiscus*, and *Spirillina*—(b.) *Pullenia*, *Sphæroidina*, ? *Rupertia*, *Endothyra*, *Cribrospira*, *Bradyina*, and *Amphistegina*—(c.) *Nonionina*, *Polystomella*, *Cyclammina*, *Operculina*, and *Nummulites*—(d.) *Fusulina*, *Schwagerina*, and *Hemifusulina*—(e.) *Heterostegina*, *Cycloclypeus*, and *Orbitoides*. There are elements of interest in such a grouping; though, in common with the rest of the scheme, it is based more on the general form of the test than on its minute structure, the existence of intermediate varieties, or other indications of genetic relationship.

The foregoing historical sketch has not been drawn up in order to discredit or in any way to depreciate the labours of which it is a brief and imperfect record, but because at every stage something is evolved that the systematist must take into account. Observers approaching the subject from various points have formed different estimates of the relative importance of the characters available for purposes of classification; and the modifications proposed in each successive scheme have been dictated by acknowledged defects in those previously existing.

The study of the Foraminifera as assemblages of forms grouped round a comparatively small number of central or typical species, as advocated by Carpenter and his colleagues, is, I am convinced, the only means of arriving at a correct understanding of the biological relations of the group; but this mode of treatment, whilst determining the general lines of classification, furnishes no direct basis for the construction of a synopsis suited to the requirements of the systematic zoologist. The scheme which I now venture to propose differs in many respects somewhat widely from that foreshadowed by the authors referred to, but in its essential elements there is little or nothing that is incompatible with the conclusions they have so ably expounded; and I have the satisfaction of knowing that it has their general approval. Every attempt to arrange in single series a class of organisms of which the constituent groups are apt to run in parallel lines, or even sometimes to form, morphologically speaking, independent circlets, is of necessity open to objection at

one point or other; and the aim of the systematist is well attained if the anomalies and inconsistencies are slight, and are confined to matters of small zoological importance.

The subjoined synopsis needs but little explanation. It is not entirely new, for a brief outline indicating its general features was given in one of the preliminary notices of some of the Challenger Foraminifera[1]; but its scope has been enlarged, and many amendments have been introduced in matters of detail.

The nature of the investment of the animal, that is to say the minute structure of the test, has been abandoned as an exclusive basis for the primary division of the Order. Under all circumstances it furnishes important characters, and in some Families is really distinctive; but it is nevertheless a fact that whilst there are certain groups which are invariably arenaceous, and some which are always calcareous and perforate, there are yet others in which no uniform rule obtains. In the absence of any simple and easily recognised characters to serve the same end, the entire Order has been divided directly into Families, without the interposition of Sub-orders.

The *Gromidæ*, a Family composed chiefly of fresh-water organisms, have been a source of considerable trouble, on account of the want of accuracy and detail in the published descriptions of a number of types, more or less closely allied to the group; and only such genera have been included as are known to have long reticulated pseudopodia. In this portion of the subject I have had the advantage of the advice of my friend Mr. W. Archer, F.R.S., of Dublin.

The Sub-family *Dactyloporinæ*, which in the original draft was placed, with some reservation, amongst the *Miliolidæ*, pending the fuller publication of the results of M. Munier-Chalmas' researches, is now entirely omitted. The examination of specimens brought under my notice by Dr. E. Perceval Wright of Dublin and M. Schlumberger of Paris has removed any doubt left on my mind as to the propriety of the transfer of the entire group to the Calcareous Algæ (*Siphonées verticillées* and *Siphonées dichotomes*).

The singular genus *Bathysiphon* of M. Sars, which was also placed provisionally amongst the *Miliolidæ*, has been removed to the *Astrorhizidæ*, inasmuch as further investigation of the structure of the test has revealed its close affinity to Carpenter's genus *Pilulina*. The position and treatment of *Parkeria* and its allies have likewise been somewhat modified, and many other minor alterations have been made, which it is hardly needful to enumerate.

The table has been devised so as to be of service as far as possible in the identification of specimens, and the salient characters of genera are very briefly stated; but from what has been already said, it will be easily understood that in certain cases the terms employed are *descriptive* rather than in any strict sense *distinctive*. No verbal description, nothing indeed but experience and the familiarity derived from a patient study of the variations

[1] *Quart. Journ. Micr. Sci.*, 1881, vol. xxi., new series, p. 43.

of the individual types, will enable the collector to distinguish between the modifications of collateral genera belonging to the same Family, or even sometimes between isomorphous varieties much less closely related.

Sub-Kingdom—PROTOZOA.

Class—RHIZOPODA.

Order—FORAMINIFERA—(RETICULARIA).

Family I. GROMIDÆ.

Test chitinous; smooth or encrusted with foreign bodies; imperforate; with a pseudopodial aperture at one or both extremities; pseudopodia long, branching, reticulated.

A. Aperture single, terminal.

Test rather large, ovate or pyriform, with the mouth in a depression at the middle of the broad end, which is more or less four-lobed, ...	*Lieberkuehnia*, Claparède and Lachmann.
Test minute, ovate; somewhat bilateral owing to the one-sided position of the produced collar-like mouth. Cavity of the test only partially filled. Pseudopodia given off from an oral column. Often found in colonies, ...	*Mikrogromia*, R. Hertwig.
Test large, ovate or rounded, symmetrical in form, flexible. Mouth terminal; pseudopodia much reticulated. Possessing one or more nuclei; contractile vacuole often wanting, ...	*Gromia*, Dujardin.
Test large, ovate, built up of foreign bodies (diatoms and the like). Pseudopodia of two sorts; the one long, branching and arborescent, issuing from the mouth; the other fine and hair-like, not reticulated, springing from between the shell particles (perhaps not true pseudopodia). Nucleus single, large. Contractile vacuole present, ...	*Diaphoropodon*, Archer.

B. With a mouth at each end of the test.

Test hyaline, elongate, tubular, cylindrical or flattened; ends slightly tapering towards the apertures. Nucleus large and complex, ... *Shepheardella*, Siddall.

Family II. MILIOLIDÆ.

Test imperforate; normally calcareous and porcellanous, sometimes encrusted with sand; under starved conditions (*e.g.*, in brackish water), becoming chitinous or chitino-arenaceous; at abyssal depths occasionally consisting of a thin, homogeneous, imperforate, siliceous film.

Sub-family 1. **Nubecularinæ**,—test free, or more usually adherent, taking various irregular asymmetrical forms, and with variable aperture or apertures.

Test a single inflated adherent chamber, with aperture on the convex surface, ... *Squamulina*, Schultze.

Typically more or less spiral, and adherent; but, whether adherent or free, assuming very irregular and anomalous contours. Test often encrusted with sand, ... *Nubecularia*, Defrance.

Sub-family 2. **Miliolininæ**,—chambers two in each convolution, coiled on an elongated axis, either symmetrically in a single plane, or inequilaterally. Aperture alternately at either end of the shell.

Chambers in a single plane, embracing; the last two only visible, ... *Biloculina*, d'Orbigny.

Chambers Biloculine in arrangement, but subdivided in the interior. Aperture porous, . . . *Fabularia*, Defrance.

Chambers arranged in a single plane, the whole of them visible on both sides of the shell, . . . *Spiroloculina*, d'Orbigny.

Chambers inequilateral, coiled round the long axis of the shell, in such a way that more than two (usually three or five) are visible externally, . . . *Miliolina*, Williamson.

Sub-family 3. **Hauerininæ**,—test dimorphous; chambers partly Milioline, partly spiral or rectilinear.

Chambers Milioline at the commencement, subsequently in a straight series, ...	*Articulina*, d'Orbigny.
Early chambers partly Milioline and partly planospiral, later segments in straight series, . . .	*Vertebralina*, d'Orbigny.
Cornuspira-like at the commencement, subsequently with two or more segments in each convolution, .	*Ophthalmidium*, Kübler.
Chambers Milioline at the commencement, subsequently planospiral, with more than two segments in each convolution, ...	*Hauerina*, d'Orbigny.
Chambers equitant, otherwise arranged as in *Hauerina*; the lateral alar prolongations of the latest convolution enclosing the previous whorls, . . .	*Planispirina*, Seguenza.

Sub-family 4. **Peneroplidinæ**,—test planospiral or cyclical, sometimes crosier-shaped, bilaterally symmetrical.

A planospiral tube, undivided, ...	*Cornuspira*, Schultze.
Chambers undivided; arrangement either planospiral throughout, or spiral only at the commencement, subsequently becoming rectilinear or cyclical, .	*Peneroplis*, Montfort.
(Sub-genera—*Archiacina*, *Broeckina*, *Broeckella*, Mun.-Chal. MS.)	
Chambers subdivided by transverse secondary septa; early segments embracing; arrangement either planospiral throughout or partly cyclical; contour nautiloid, auricular, crosier-shaped, or complanate, . .	*Orbiculina*, Lamarck.
Test discoidal; either spiral (non-embracing) just at the commencement, or with one or more inflated primordial chambers; subsequently cyclical; chambers more or less regularly divided into chamberlets, .	*Orbitolites*, Lamarck.

Sub-family 5. **Alveolininæ**,—test spiral, elongated in the line of the axis of convolution, chambers divided into chamberlets.

Test subglobular, elliptical, or fusiform; recent species often with subdivided chamberlets, . .	*Alveolina*, d'Orbigny.

Sub-family 6. **Keramosphærinæ**,—test spherical, chambers in concentric layers.

Test spherical, composed of a multitude of more or less irregularly-shaped chamberlets arranged in concentric layers, ... *Keramosphæra*, Brady.

Family III. ASTRORHIZIDÆ.

Test invariably composite, usually of large size and monothalamous; often branched or radiate, sometimes segmented by constriction of the walls, but seldom or never truly septate; polythalamous forms never symmetrical.

Sub-family 1. **Astrorhizinæ**,—walls thick, composed of loose sand or mud, very slightly cemented.

Test fusiform or depressed. Depressed forms either sub-lenticular with angular or irregularly radiate margin, or in branching masses. Apertures at the end of each ray or branch, ... *Astrorhiza*, Sandahl.

Test formed of mud with a chitinous lining; more or less flask-shaped or subcylindrical, . . . *Pelosina*, Brady.

Test subglobular, very irregular externally; apertures numerous, situated in horn-like protuberances; interior smooth, ... *Storthosphæra*, Schulze.

Test adherent; formed of mud with a chitinous basis; either irregularly outspread, or columnar and branching, ... *Dendrophrya*, Str. Wright.

Test consisting of a large rounded mass of branching, radiating tubes, arranged in more or less distinct layers or tiers; texture coarsely arenaceous, the sand-grains very loosely aggregated, . . *Syringammina*, Brady.

Sub-family 2. **Pilulininæ**,—test monothalamous; walls thick, composed chiefly of felted sponge-spicules and fine sand, without calcareous or other cement.

Test nearly spherical; aperture a long and more or less curved slit, ... *Pilulina*, Carpenter.

Test oval or subcylindrical; aperture, typically, a rounded orifice at one end, ... *Technitella*, Norman.

Test long, cylindrical, slightly tapering; in the form of a straight or curved tube open at both ends, . *Bathysiphon*, Sars.

Sub-family 3. **Saccammininæ**,—chambers nearly spherical; walls thin, composed of firmly cemented sand-grains.

Test a single globular chamber without any general aperture, the pseudopodia issuing from interstitial orifices, *Psammosphæra*, Schulze.

A number of globular chambers adherent to each other, without distinct stoloniferous tubes, and with no general aperture, ... *Sorosphæra*, Brady.

One or several globular, pyriform or fusiform chambers, with distinct apertures. Polythalamous forms with or without stoloniferous connections, . . *Saccammina*, M. Sars.

Sub-family 4. **Rhabdammininæ**,—test composed of firmly cemented sand-grains, often with sponge-spicules intermixed; tubular; straight, radiate, branched, or irregular; free or adherent; with one, two, or more apertures; rarely segmented.

Test elongate, tapering; aperture at the broad end, . *Jaculella*, Brady.

Test elongated, tubular, the closed end broad and rounded, sometimes inflated so as to form a distinct chamber; tube simple or branched, free or adherent, ... *Hyperammina*, Brady.

Test fusiform or cylindrical, with an aperture at each end; largely composed of sponge-spicules, especially near the extremities, ... *Marsipella*, Norman.

Test rectilinear, radiate, or irregularly branching; with or without a central chamber. The open ends of the tubes forming the apertures, . . . *Rhabdammina*, M. Sars.

Test very variable in form; usually consisting of irregular inflated sacs, either single and presenting several tubulated orifices, or combined in branching series, . *Aschemonella*, Brady.

Unattached masses of fine flexible, simple or branching, chitino-arenaceous tubes, ... *Rhizammina*, Brady.

Test a branching, reticulated, adherent, sandy tube, spreading over the surface of shells or stones; apertures terminal, ... *Sagenella*, Brady.

Test subcylindrical, growing attached at one end (?); the other end rounded, and formed of loose sand-grains with interstitial openings. Interior filled with irregular septa, formed of coarse sand-grains slightly cemented together, ... *Botellina*, Carpenter.

Test columnar, growing attached by an expanded convex pseudo-polythalamous base; column straight or crooked; either simple and gradually increasing in size towards the apex, or dividing into a number of branches. Test generally beset with sponge-spicules; aperture terminal, ... *Haliphysema*, Bowerbank.

Family IV. LITUOLIDÆ.

Test arenaceous, usually regular in contour; septation of the polythalamous forms often imperfect, chambers frequently labyrinthic. Comprises sandy isomorphs of the simple porcellanous and hyaline types (*Cornuspira*, *Miliolina*, *Peneroplis*, *Lagena*, *Nodosaria*, *Cristellaria*, *Globigerina*, *Rotalia*, *Nonionina*, &c.), together with some adherent species.

Sub-family 1. Lituolinæ,—test composed of coarse sand-grains, rough externally; often labyrinthic.

A. *Non-labyrinthic*

Test free; composed either of a single flask-shaped chamber, or of several, united in a straight, curved, or irregular line; never spiral, . . . *Reophax*, Montfort.

Test free; partially or entirely spiral; nautiloid or crosier-shaped; chambers numerous, . . . *Haplophragmium*, Reuss.

General characters those of *Haplophragmium*, but the later chambers widening rapidly, . . . *Coskinolina*, Stache.

Chambers plano convex, adherent, . . . *Placopsilina*, d'Orbigny.

B. *Chambers labyrinthic.*

Test free, uniserial, straight, or arcuate; never spiral, . *Haplostiche*, Reuss.

Test free; partially or entirely spiral; nautiloid or crosier-shaped, ... *Lituola*, Lamarck.

Test adherent; chambers linear, vermiform, approximated, intercommunicating by a row of pores on each septal face, ... *Bdelloidina*, Carter.

Sub-family 2. **Trochammininæ,**—test thin; composed of minute sand-grains incorporated with calcareous or other inorganic cement, or embedded in a chitinous membrane; exterior smooth, often polished; interior smooth or (rarely) reticulated; never labyrinthic.

Test typically consisting of a single *Orbulina*-like chamber with several mammillate apertures, . . .	*Thurammina*, Brady.
(Sub-genus—*Thuramminopsis*, Haeusler).	
Test monothalamous, elongate; broad and rounded at one end, tapering to a point at the other; aperture large, curved or irregular, ...	*Hippocrepina*, Parker.
Test consisting of a single rounded chamber, or, more usually, of several chambers in a single straight or arcuate series, ...	*Hormosina*, Brady.
Test free, formed of a tube coiled upon itself in various ways; sometimes constricted at intervals, never truly septate, ...	*Ammodiscus*, Reuss.
Test free or rarely adherent; Rotaliform, nautiloid, or trochoid; more or less distinctly septate, . .	*Trochammina*, Parker & Jones.
Test Rotaliform, convex; free, or adherent; with elongate-oval calcareous spicules proper to itself, . .	*Carterina*, Brady.
Test adherent; consisting either of a single tent-like chamber, or of a number of such chambers connected by adherent stoloniferous tubes, . . .	*Webbina*, d'Orbigny.

Sub-family 3. **Endothyrinæ,**—test more calcareous and less sandy than in the other groups of *Lituolidæ;* sometimes perforate; septation distinct.

Test Nodosariform, finely arenaceous, nearly smooth externally; interior sometimes slightly labyrinthic; aperture simple, ...	*Nodosinella*, Brady.
Test cylindrical, growing attached by the basal extremity; consisting of a line of very short cylindrical segments placed one above the other. Interior of the chambers labyrinthic; aperture terminal, cribrate, .	*Polyphragma*, Reuss.
Test lenticular, consisting of a planospiral tube with a deposit of shell-substance on both faces, thickest near the middle. Tube sometimes slightly constricted at intervals. Shell-wall more or less perforate, .	*Involutina*, Terquem.

Test polythalamous; nautiloid or Rotaliform; aperture simple, situated at the inner margin of the final chamber, ... *Endothyra*, Phillips.

Test nautiloid; aperture consisting of a number of pores on the face of the terminal chamber; with pores (?) also in the septal depressions, ... *Bradyina*, Möller.

Test adherent, composed either of numerous segments subdivided into chamberlets, or of an acervuline mass of chamberlets either arranged in layers or confused, *Stacheia*, Brady.

Sub-family 4. **Loftusinæ**,—test of relatively large size; lenticular, spherical, or fusiform; constructed either on a spiral plan or in concentric layers, the chamber-cavities occupied to a large extent by the excessive development of the finely arenaceous cancellated walls.

Test spiral, nautiloid; lenticular or subglobular; smooth externally; chambers numerous, involute, . . *Cyclammina*, Brady.

Test of large size, spiral; elongated in the direction of the axis; fusiform or elliptical; resembling *Alveolina* in contour, ... *Loftusia*, Brady.

Test spheroidal or more or less compressed, composed of concentric layers, ... *Parkeria*, Carpenter.

Family V. TEXTULARIDÆ.

Tests of the larger species arenaceous, either with or without a perforate calcareous basis; smaller forms hyaline and conspicuously perforated. Chambers arranged in two or more alternating series, or spiral, or confused; often dimorphous.

Sub-family 1. **Textularinæ**,—typically bi- or tri- serial; often bi-, rarely tri- morphous.

Segments in two rows alternating with each other; normal aperture an arched slit at the base of the inner wall of the final segment, ... *Textularia*, Defrance.

Test Textularian, complanate; compressed in a direction at right angles to the normal plane, so that the two alternating series of segments appear on the two narrow lateral edges, ... *Cuneolina*, d'Orbigny.

Test triserial, with Textularian aperture, . . *Verneuilina*, d'Orbigny.

Test triserial (sometimes dimorphous), with simple, produced, central aperture, ... *Tritaxia*, Reuss.

Test triserial (sometimes dimorphous) with porous aperture, ... *Chrysalidina*, d'Orbigny.

Dimorphous (Textularian) forms.

Early chambers Textularian, later chambers uniserial and rectilinear, . . . *Bigenerina*, d'Orbigny.

Early chambers small and Textularian, later chambers broadly arched and uniserial, forming a fan-shaped test; aperture porous, . *Pavonina*, d'Orbigny.

Early segments planospiral, later ones Textularian, *Spiroplecta*, Ehrenberg.

Early segments triserial (Verneuiline), later ones Textularian; aperture either Textularian or situated in a short terminal neck, . . *Gaudryina*, d'Orbigny.

Test spiral, typically triserial, with three segments or rarely more in each convolution; free or adherent; aperture partially covered by a valvular lip, . . *Valvulina*, d'Orbigny.

Dimorphous (Valvuline) form.

Early segments triserial (Valvuline), later ones uniserial and rectilinear; test generally either cylindrical or trifacial; aperture valvular, . *Clavulina*, d'Orbigny.

Sub-family 2. **Buliminin**æ,—typically spiral; weaker forms more or less regularly biserial; aperture oblique, comma-shaped or some modification of that form.

Test spiral, elongate, more or less tapering; often triserial, *Bulimina*, d'Orbigny.

Test much elongated, with a tendency to become asymmetrically biserial, ... *Virgulina*, d'Orbigny.

Dimorphous form.

Early segments Bulimine or Virguline, later ones uniserial, ... *Bifarina*, Parker & Jones.

Test distinctly biserial, arrangement Textularian, . *Bolivina*, d'Orbigny.

Test biserial: aperture large, usually arched or semicircular with a notch at the middle of the lower edge; situated at the top of the nearly erect septal face of the last segment, ... *Pleurostomella*, Reuss.

Sub-family 3. **Cassidulininæ,**—test consisting of a Textularia-like series of alternating segments, more or less coiled upon itself.

Test biserial, folded on its long axis, and coiled more or less completely on itself; rarely dimorphous,	*Cassidulina*, d'Orbigny.
(Sub-genus, *Orthoplecta*, Brady.)	
Test biserial, broad, arched on the dorsal side; general form that of an unfolded and uncoiled *Cassidulina*,	*Ehrenbergina*, Reuss.

Family VI. CHILOSTOMELLIDÆ.

Test calcareous, finely perforate, polythalamous. Segments following each other from the same end of the long axis, or alternately at the two ends, or in cycles of three; more or less embracing. Aperture a curved slit at the end or margin of the final segment.

Test uniaxial, segments oval, each springing from the base of the previous one and entirely enveloping it; aperture terminal,	*Ellipsoidina*, Seguenza.
Segments oval, put on alternately at either end of the test,	*Chilostomella*, Reuss.
Segments alternating at three sides so as to leave portions of two, in addition to the final one, exposed,	*Allomorphina*, Reuss.

Family VII. LAGENIDÆ.

Test calcareous, very finely perforated; either monothalamous, or consisting of a number of chambers joined in a straight, curved, spiral, alternating or (rarely) branching, series. Aperture simple or radiate, terminal. No interseptal skeleton nor canal system.

Sub-family 1. **Lageninæ,**—test monothalamous.

Test monothalamous, ecto- or ento-solenian,	*Lagena*, Walker and Boys.

Sub-family 2. **Nodosarinæ,**—test polythalamous; straight, arcuate, or planospiral.

Test straight or curved, circular in transverse section; aperture typically central,	*Nodosaria*, Lamarck.
Test straight, compressed; aperture typically a narrow fissure,	*Lingulina*, d'Orbigny.
Test compressed or complanate, segments V-shaped, equitant; primordial chamber distinct	*Frondicularia*, Defrance.

Test straight or slightly curved, angular or subcarinate; usually tri- or quadrangular in section,	*Rhabdogonium*, Reuss.
Test elongate, curved; segments circular in section; aperture marginal,	*Marginulina*, d'Orbigny.
Test elongate, compressed or complanate; septation oblique; aperture marginal,	*Vaginulina*, d'Orbigny.
Test resembling a thick somewhat rounded *Vaginulina*; septation very oblique; aperture a long slit down the ventral face of the final segment,	*Rimulina*, d'Orbigny.
Test planospiral in part or entirely; complanate, lenticular, crosier-shaped or ensiform,	*Cristellaria*, Lamarck.

Dimorphous forms.

Early chambers Cristellarian, later ones Nodosarian,	*Amphicoryne*, Schlumberger.
Early chambers Cristellarian, later ones Linguline,	*Lingulinopsis*, Reuss.
Early chambers Cristellarian, later ones Frondicularian,	*Flabellina*, d'Orbigny.
Early chambers Frondicularian, later ones Nodosarian,	*Amphimorphina*, Neugeboren.
Early chambers Rhabdogonian, later ones Nodosarian (Dentaline),	*Dentalinopsis*, Reuss.

Sub-family 3. **Polymorphininæ**,—segments arranged spirally or irregularly around the long axis; rarely biserial and alternate.

Segments bi- or triserial or irregularly spiral; aperture radiate,	*Polymorphina*, d'Orbigny.

Dimorphous form.

Early chambers Polymorphine, later ones Nodosarian,	*Dimorphina*, d'Orbigny.
Segments arranged in a more or less regular spire round the long axis of the shell, rarely biserial. Aperture simple, usually surrounded by a phialine lip; often forming a prolonged terminal tube,	*Uvigerina*, d'Orbigny.

Dimorphous form.

Early segments Uvigerine, later ones Nodosarian,	*Sagrina*, Parker and Jones (d'Orbigny ?).

Sub-family 4. **Ramulininæ**,—test irregular, branching.

Test branching, composed of spherical or pyriform chambers connected by long stoloniferous tubes, . .	*Ramulina*, Rupert Jones.

Family VIII. GLOBIGERINIDÆ.

Test free, calcareous, perforate; chambers few, inflated, arranged spirally; aperture single or multiple, conspicuous. No supplementary skeleton nor canal system. All the larger species pelagic in habit.

Test coarsely perforated; trochoid, Rotaliform, or symmetrically planospiral; segments few, inflated; pelagic specimens spinous, ...	*Globigerina*, d'Orbigny.
Test, having the external form of a single spherical chamber with two sorts of perforations, large and small; pelagic specimens usually with very thin shell-wall and radiating spines, ...	*Orbulina*, d'Orbigny.
Test regularly nautiloid, involute; shell-wall thin, finely perforated; armed with long serrate spines. Aperture a large crescentiform opening at the base of the last chamber. Pelagic, . . .	*Hastigerina*, Wy. Thomson.
Test regularly or obliquely nautiloid and involute; segments only slightly ventricose. Shell-wall very finely perforated; aperture a long curved slit close to the line of union of the last segment with the previous convolution, . . .	*Pullenia*, Parker and Jones.
Segments few, coiled so as to form a nearly globular shell; aperture arched; sometimes partially closed with a valvular tongue, ...	*Sphæroidina*, d'Orbigny.
Test trochoid; segments inflated; shell-wall thin, finely perforated. Aperture consisting of rows of pores along the septal depressions, . . .	*Candeina*, d'Orbigny.

Family IX. ROTALIDÆ.

Test calcareous, perforate; free or adherent. Typically spiral and "Rotaliform," that is to say, coiled in such a manner that the whole of the segments are visible on the

superior surface, those of the last convolution only on the inferior or apertural side, sometimes one face being more convex, sometimes the other. Aberrant forms evolute, outspread, acervuline, or irregular. Some of the higher modifications with double chamber-walls, supplemental skeleton, and a system of canals.

Sub-family 1. **Spirillininæ,**—test spiral, non-septate.

Test a complanate, planospiral, non-septate tube; free or attached, ... *Spirillina*, Ehrenberg.

Sub-family 2. **Rotalinæ,**—test spiral, Rotaliform, rarely evolute, very rarely irregular or acervuline.

Test conical, consisting of an external layer of spirally arranged or annular chambers divided into chamberlets; the interior of the cone filled either with hyaline shell-substance or by an aggregation of compressed chambers, ... *Patellina*, Williamson.

Test more or less trochoid or complanate. Segments of the trochoid forms spiral at the apex, subsequently arranged concentrically round a deep umbilical vestibule with which each chamber communicates by a neck. Complanate forms with rows of pores along the septal depressions of the inferior surface. Pelagic type, with large inflated chamber covering the base of the shell, ... *Cymbalopora*, Hagenow.

Test free or adherent, Rotaliform; planoconvex or trochoid rarely complanate; aperture an arched slit, often protected by an umbilical flap—the flaps sometimes forming a whorl of subsidiary chambers. Shell somewhat coarsely porous, . . . *Discorbina*, Parker & Jones.

Test normally adherent; compressed or complanate segments very numerous; commencing growth on a spiral plan, but subsequently becoming more or less cyclical; the lipped apertures of the individual segments opening externally at the periphery. Aberrant varieties often wild-growing and irregular, sometimes acervuline. Shell-wall coarsely porous, . . *Planorbulina*, d'Orbigny.

Test free or adherent, Rotaliform; the inferior face generally more convex than the superior. Shell-wall coarsely porous; surface sometimes tuberculated, especially in old shells. Aperture a curved slit at or near the superior margin of the inner edge of the final segment, sometimes with phialine neck and lip, .	*Truncatulina*, d'Orbigny.
Characters similar to those of *Truncatulina*, except that the two faces are more nearly alike, the general contour being biconcave or subnautiloid and the whorls more or less evolute, . . .	*Anomalina*, Parker & Jones.
Test adherent, spiral; convex or monticular in form; segments few, somewhat inflated, either spreading radially or superimposed vertically; aperture at the apex of the final segment sometimes situated in a prolonged simple or arborescent tube. Canal system, when present, rudimentary, . . .	*Carpenteria*, Gray.
Test columnar, growing attached by a slightly spreading base; segments numerous, spirally arranged; aperture at the inner margin of the terminal segment, .	*Rupertia*, Wallich.
Test Rotaliform, superior side usually thickest; shell, with rare exceptions, very finely porous; segments fewer in number than in the other Rotalinæ. Shell-thickening usually taking the form of external sutural limbation. Aperture typically a large slit at the base of the umbilical margin of the last segment; often irregular, both as to form and position. Face of the terminal segment sometimes inflated and studded with Orbuline perforations. Some species pelagic, .	*Pulvinulina*, Parker & Jones.
Test Rotaliform, shell-wall very finely porous; exogenous deposit either in the form of embossed septal lines or of granulation of the sutures near the umbilicus. Aperture a neatly arched slit, nearly median. Larger species have double septa and a system of interseptal canals, ...	*Rotalia*, Lamarck.
Test Rotaliform, lenticular; periphery furnished with radiating (sometimes branching) spines; supplemental skeleton and canal system very largely developed, .	*Calcarina*, d'Orbigny.

Sub-family 3. **Tinoporinæ**,—test consisting of irregularly heaped chambers, with (or sometimes without) a more or less distinctly spiral primordial portion; for the most part without any general aperture.

Test lenticular or subspheroidal, with radiating marginal spines and tuberculated surface; central chambers forming a planospiral disk, which is thickened by an aggregation of smaller chambers arranged in tiers on the two sides. No general aperture. Supplemental skeleton traversed by canals, . .	*Tinoporus*, Carpenter (Montfort ?).
Test free or attached, spheroidal or spreading; structure acervuline, radiating, or laminated. Chambers rounded or polyhedral; coarsely perforated. No supplemental skeleton, no canal system, and no general aperture, ...	*Gypsina*, Carter.
Test adherent, planoconvex, spreading; margin thin and irregular; surface areolated. Chambers more or less acervuline, variable in size; walls finely perforated. Apertures numerous, marginal. No canal system, .	*Aphrosina*, Carter.
Test columnar, branching, growing attached by the base; segments very numerous, crowded more or less regularly round the long axis; no general aperture, the coarse perforation of the shell taking its place, .	*Thalamopora*,[1] Roemer.
Test parasitic, encrusting or arborescent; surface areolated, colour pink or (less frequently) white. Interior partly occupied by small chambers arranged in more or less regular layers, and partly by non-segmented canal-like spaces, often crowded with sponge-spicules. No true canal system, . . .	*Polytrema*, Risso.

Family X. NUMMULINIDÆ.

Test calcareous and finely tubulated; typically free, polythalamous, and symmetrically spiral. The higher modifications all possessing a supplemental skeleton and a canal system of greater or less complexity.

Sub-family 1. **Fusulininæ**,—test bilaterally symmetrical; chambers extending from pole to pole; each convolution completely enclosing the previous whorls. Shell-wall

[1] The zoological relationship of the fossil genus *Thalamopora* is still a matter of debate; the position it here occupies is suggested by Reuss's description and figures.

finely tubulated. Septa single or rarely double; no true interseptal canals. Aperture a single elongated slit, or a row of small rounded pores, at the inner edge of the final segment.

Test fusiform or subglobular; chambers entire, or only subdivided by the infolding of the septal wall; aperture an elongated central fissure, . . *Fusulina*, Fischer.

(Sub-genera—*Hemifusulina*, *Fusulinella*, Möller.)

Test subglobular, elongated, or subcylindrical, seldom fusiform; chambers subdivided by true secondary septa; aperture either a simple central fissure or a row of rounded pores, ... *Schwagerina*, Möller.

Sub-family 2. **Polystomellinæ**,—test bilaterally symmetrical; nautiloid. Lower forms without supplemental skeleton or interseptal canals; higher types with canals opening at regular intervals along the external septal depressions.

Supplemental skeleton either absent or rudimentary, and confined to the umbilical region; no external septal pores or bridges. Aperture a simple curved slit, . *Nonionina*, d'Orbigny.

Supplemental skeleton, septal bridges, and canal-system more or less fully developed; canals opening externally at the umbilicus and by a single or double row of pores along the sutures. Aperture a V-shaped line of perforations at the base of the septal face, . *Polystomella*, Lamarck.

(Sub-genus—*Faujasina*, d'Orbigny.)

Sub-family 3. **Nummulitinæ**,—test lenticular or complanate; lower forms with thickened and finely tubulated shell-wall, but no intermediate skeleton; higher forms with interseptal skeleton and complex canal system.

Test lenticular; consisting of a non-septate tube coiled upon itself in constantly varying direction, embedded in a thick mass of finely tubulated shell-substance. No supplemental skeleton nor canal system, . *Archædiscus*, Brady.

Test spiral, lenticular, inequilateral; chambers equitant, the alar prolongations on one side simple, on the other divided by deep constrictions so as to form supplementary lobes. Shell-wall thickened near the umbilicus and finely tubulated, but presenting no true canal system, ... *Amphistegina*, d'Orbigny.

Shell typically complanate and planospiral, with the whole of the convolutions visible; the earlier whorls more or less embracing. Interseptal and marginal canals conspicuously developed, . . *Operculina*, d'Orbigny.

Test resembling *Operculina* in general contour; chambers long and narrow, and divided into chamberlets; aperture a row of pores on the outer septal face, . *Heterostegina*, d'Orbigny.

Test lenticular or complanate, planospiral, regular. Segments equitant, the alar prolongations of each convolution completely enclosing the previous whorls. Aperture simple, close to the periphery of the previous convolution. Supplemental skeleton provided with complex canal system, . . *Nummulites*, Lamarck.

Test complanate, structure similar to that of *Nummulites*, but the alar extensions of the chamber-walls thin and closely superimposed, so that the outline of the convolutions is visible externally, . . . *Assilina*, d'Orbigny.

Sub-family 4. **Cycloclypeinæ**,—test complanate with thickened centre, or lenticular; consisting of a disk of chambers arranged in concentric annuli, with more or less lateral thickening of laminated shell-substance, or acervuline layers of chamberlets. Septa double, and furnished with a system of interseptal canals.

Discoidal layer usually single; with superimposed laminæ of finely tubulated shell-substance, thickest at the centre, often only slightly developed, . *Cycloclypeus*, Carpenter.

Median plane composed of chamberlets arranged in regular annuli round a distinct central chamber; thickened on either side by layers of flattened chamberlets, more or less irregularly disposed, ... *Orbitoides*, d'Orbigny.

(Sub-genera—*Discocyclina*, *Rhipidocyclina*, *Aktinocyclina*, *Asterocyclina*, *Lepidocyclina*, Gümbel.)

Sub-family 5. (?) **Eozoöninæ**,—test forming irregular, adherent, acervuline masses.

(?) Test adherent, outline irregular; composed of segments arranged at first in more or less regular superimposed layers, subsequently acervuline; with interseptal skeleton and ramifying canals, . . *Eozoön*, Dawson.

The foregoing Synopsis has been made as nearly complete as circumstances admit, and most of the generic terms not included in it will be found as synonyms in the descriptive portions of the Report, and may be referred to by means of the Index at the end of the volume. There are, however, a few genera based for the most part upon obscure fossil species—such as, for example, the *Renulina* of Blake, *Annulina*, Terquem, *Calcisphæra*, Dawson, and *Cœlotrochium*, Schlüter—which have been omitted for want of sufficient knowledge of their salient characters to determine their zoological position; and in the same category may be placed the large fossil organisms of which *Receptaculites* is a type, concerning whose affinities too little has as yet been accurately ascertained to warrant their recognition as a well-established family of Rhizopods.

Of even more interest, perhaps, is the group of recent Protozoa, named by Mr. Carter, **Testamœbiformia** ("Ann. and Mag. Nat. Hist.," 1880, ser. 5, vol. v. p. 446, pl. 18, 19), and placed by him amongst Foraminifera. It includes a number of adherent testaceous Rhizopoda taking the general form of *Amœba*,—that is to say, with irregular, lobed, or branched extensions of the periphery. Of these Mr. Carter has described three generic types, namely—*Holocladina*, in which the test is calcareous and branched, and has a pustuliferous or papillate surface, each projection with a puncture in the centre; *Cysteodictyina*, which is calcareous, sessile, blister-like with interstices (not branched), and has a uniformly punctate surface; and *Ceratestina*, which is chitinous and polythalamous, the chambers being developed upon a filamentous stoloniferous tube. The most careful study of the descriptions and figures furnished by the author has not enabled me to assign a place to this singular group of parasitic forms, and it seems better to await the results of further research than to treat it even provisionally on our present knowledge. As yet, only the tests are known, and it appears possible, if not probable, that the resemblance to *Amœba* may not stop at external contour, but may apply equally to the sarcode-body, and that they may belong to the Lobose rather than the Reticularian section of Rhizopoda.

GEOGRAPHICAL AND BATHYMETRICAL.

The subjoined notes form a summary of the conditions under which the various soundings and dredgings which have been made use of in the present Report were obtained. They contain particulars as to locality, depth, and temperature, together with a brief indication of the physical characters of the material obtained at the several Stations, and of the more prominent types of microzoa observed at each. The terms used to describe the nature of the sea-bottom are those employed in the "List of Observing Stations," drawn up by the late Sir Wyville Thomson for the guidance of naturalists engaged on the various reports, in which work they are defined as follows :—

Rock indicates hard ground, where nothing was brought up by the sounding instrument, there being at the same time evidence that the tube had reached the bottom.

Mud, a material varying in colour, but derived chiefly from the disintegration of the land.

Globigerina Ooze, a white or greyish deposit, formed in a great measure of the shells, entire or broken, of Foraminifera belonging to the genera *Globigerina*, *Orbulina*, *Hastigerina* and *Pulvinulina*, usually with a quantity of amorphous calcareous or earthy matter, and many coccoliths.

Diatom Ooze indicates a deposit formed to a great extent of the frustules of diatoms which have sunk from the surface.

Radiolarian Ooze indicates a deposit composed mainly of the skeletons of Polycystina and other Radiolarians.

Red Clay indicates a deposit, very widely extended in deep water, of red, reddish, or grey aluminous mud, such as would be produced by the decomposition of a felspathic mineral. This deposit varies considerably in character; it seems to be derived from several sources, but one of the most important of these appears to be the decomposition of pumice and other volcanic products. The "red clay" often contains concretionary nodules, consisting chiefly of the oxides of manganese and iron.

Grey Ooze and Grey Mud usually indicate an intermediate condition between Globigerina ooze and Red Clay; or in some cases a fine-grained grey deposit, formed in deep water, chiefly of land débris. [The microzoic remains indicate a fauna in all respects similar to that of a Globigerina ooze].

In tropical and sub-tropical regions, in depths less than 2000 fathoms, the shells of Pteropods and other pelagic Mollusca are generally present in considerable numbers in the oceanic deposits. In depths less than 1500 fathoms, far from land, these molluscan remains appear to furnish fully one-half of the carbonate of lime, and they impart a distinct character to the sea-bottom. To calcareous deposits of this sort the name Pteropod Ooze has been applied. The Challenger met with typical examples of Pteropod ooze at depths of 1240 fathoms and 1415 fathoms in the South Atlantic, on the ridge between Tristan d'Acunha and Ascension Island.

The Stations enumerated refer to areas explored on several distinct expeditions, which are taken in the following order:—I. Challenger Expedition; II. "Porcupine" Expedition; III. "Knight-Errant" Expedition; IV. Arctic Seas, visited on the last British North-Polar Expedition, and the Austro-Hungarian North-Polar Expedition.

I. Challenger Expedition.

It may be useful at the outset to describe in a few sentences the general track of the Challenger cruise.

Leaving Portsmouth, the vessel proceeded down the coast of Spain and Portugal to Gibraltar, sailed thence for Madeira and the Canaries, and across the Atlantic to Sombero and Culebra, the outermost of the West Indian Islands; from this point northwards to Bermuda, and thence to Halifax, Nova Scotia.

Returning to Bermuda, the Atlantic was again crossed on a more northerly line than previously, by way of the Azores, as far as Madeira. From Madeira the vessel was turned southwards to the Cape de Verde Islands, and down the African coast to within about four degrees of the Equator; then in a more westerly direction, crossing the Line at about long. 31° W., to Pernambuco and Bahia, touching at St. Paul's Rocks and Fernando Noronha. From Bahia the South Atlantic was traversed to the Cape of Good Hope, stopping at the Island of Tristan d'Acunha on the way.

From the Cape to Melbourne the course taken was first to Kerguelen Island, and then still further south, reaching the Antarctic Circle at about long. 80° E.

After leaving Melbourne the Challenger proceeded to Sydney, thence to New Zealand, and by Cook Strait and the Kermadec Islands to Fiji; from Fiji through Torres Strait, and west of the Philippine Islands to Hong Kong. After a short stay at

Hong Kong the vessel returned by almost the same route to the northern shores of Papua, stopping for a time at the Admiralty Islands, and thence sailed direct for Japan.

From Japan a long series of soundings were taken, on a line directly east, stretching more than half across the Pacific, and then almost due south to the Sandwich Islands. Subsequently the same southerly direction was followed in mid-Pacific, crossing the Equator in about long. 150° E., and through the Low Archipelago to lat. 40° S. From this point the bearing was again eastward to the Island of Juan Fernandez and Valparaiso. Leaving Valparaiso the Islands on the west coast of Patagonia were visited, and the South Atlantic entered by Magellans Strait.

Some time was occupied at the Falkland Islands, and then steering northwards the vessel put into Buenos Ayres. Leaving Buenos Ayres an eastward course was taken to near mid-ocean, afterwards northwards by Ascension to the Cape de Verde Islands and the Azores; from which point the homeward journey was only interrupted by a call in Vigo Bay.

The subjoined list embraces only those Stations from which soundings or dredgings were obtained in sufficient quantity to furnish good representative series of Rhizopoda, and the numbers appended are those used in the official record. From time to time, during the voyage, other material, such as harbour-muds and shallow-water sands, were collected, at localities not included in the published list; and, as some of these have proved very rich in Foraminifera, they are inserted in the present summary, and are distinguished by the addition of a Roman letter to the number of the nearest Station.

For purposes of reference, and especially to facilitate the correlation of the surface organisms collected by means of the tow-net, with those obtained from the bottom dredgings, the course has been divided into seventeen sections, or lines of soundings, marked by black-letter capitals **A** to **Q**.

Observing Stations.

A. Stations I. to VIII. (preliminary). *Between Cape Finisterre and the Canaries.*

Station VII. A.—February 10, 1873. Off Teneriffe. Depth, 78 fathoms. Sandy mud, with very few organisms. Foraminifera of only about half a dozen common shallow-water species.

Station VIII.—February 12, 1873. Off Gomera, Canaries. Depth, 620 fathoms. Sandy mud and shells, with large numbers of stellate sponge-spicules and a few Radiolaria. The Foraminifera for the most part those of a mid-Atlantic Globigerina ooze, but, in common with other shelly organisms, all a good deal worn.

B. Stations 1 to 24, *North Atlantic, from the Canaries to the West Indies.*

Station 3.—February 18, 1873. Lat. 25° 45′ N., long. 20° 12′ W. Depth, 1525 fathoms; bottom temperature, 2°·2 C.; rock.

A small quantity of fine shelly sand, with many sponge-spicules. The Foraminifera were chiefly *Globigerinæ* (notably *Globigerina rubra*) and *Pulvinulinæ*, with one or two specimens of *Candeina nitida* and *Pullenia obliquiloculata*.

Station 5.—February 21, 1873. Lat. 24° 20′ N., long. 24° 28′ W. Depth, 2740 fathoms; bottom temperature, 2°·0 C.; red clay.

The small percentage that remained after washing[1] contained nothing beyond the ordinary constituents of a Globigerina ooze—the genera *Globigerina*, *Pulvinulina*, *Sphæroidina*, and *Pullenia*, with a few *Nonioninæ*.

Station 9.—February 26, 1873. Lat. 23° 23′ N., long. 35° 10′ W. Depth, 3150 fathoms; bottom temperature, 1°·9 C.; red clay.

Left scarcely any residue after washing. The Foraminifera were of the same general character as those of Station 5, with the addition of a few arenaceous forms. There were also a few Radiolaria.

Station 23.—March 15, 1873. Off Sombrero Island, West Indies. Depth, 450 fathoms; Globigerina ooze.

Contained all the common species of *Globigerina* (notably *Globigerina rubra*), the pelagic *Pulvinulinæ* (represented principally by *Pulvinulina menardii*), *Sphæroidina* and *Pullenia*. *Pulvinulina elegans* and *Pulvinulina pauperata*, two or three species of *Truncatulina*, the genera *Textularia*, *Gaudryina*, and *Miliolina*, with fragments of *Rhabdammina*, *Hyperammina*, and one or two other arenaceous types, supply the chief additional Foraminifera. A number of Radiolaria were also noticed.

Station 24.—March 25, 1873. Off Culebra Island, North of St. Thomas's, West Indies. Depth, 390 fathoms; mud.

White material, with large numbers of pteropod shells. Very rich in Foraminifera, particularly in the larger forms of *Nodosarinæ* and *Textularinæ*,

[1] Before microscopic examination the material was in each case washed on a sieve of fine wire gauze, 120 meshes to the linear inch, which retained all particles of greater diameter than $\frac{1}{200}$ inch (0·126 millim.). The impalpable matter separated in this way was generally found to consist of rock-detritus, or the finely comminuted remains of calcareous or siliceous organisms, Radiolaria, Diatomaceæ, and Coccoliths being often present to a greater or less extent, as well as Foraminifera, but of the latter only minute examples of species represented by adult specimens remaining in the sieve. The "residue after washing," frequently mentioned, means therefore the portion of the material available for examination after the removal of the "mud."

and in arenaceous types. Of the former, the genera *Nodosaria*, *Lingulina*, *Frondicularia*, and *Cristellaria* are represented by remarkably fine examples; the Textularian group contributes specimens of *Textularia*, *Pavonina*, *Bigenerina*, *Verneuilina*, and *Clavulina*, which are equally noteworthy; whilst the Arenacea furnish *Rhabdammina*, *Hyperammina*, *Cyclammina*, and *Ammodiscus*, together with many of the smaller forms; and the Porcellanea are conspicuous in *Orbiculina* and large *Biloculinæ*. These are but the more important out of a long list of Foraminifera.

C. Stations 25 to 36, *North Atlantic, from St. Thomas Island to Bermuda.*

Station 27.—March 28, 1873. Lat. 22° 49′ N., long. 65° 19′ W. Depth, 2960 fathoms; bottom temperature, 1°·5 C.; grey ooze.

An impalpable mud containing nothing organic.

Station 33.—April 4, 1873. Off Bermudas. Depth, 435 fathoms; mud.

White calcareous material, largely composed of the remains of molluscan shells, pteropods, and corals with a few Ostracoda. Amongst the Foraminifera, *Globigerinæ* and *Pulvinulinæ* were plentiful, and with them *Orbitolites* of the simple type, *Orbiculinæ* and *Amphisteginæ*, the specimens of the latter being unusually thin. The genera *Frondicularia*, *Cristellaria*, *Textularia*, *Clavulina*, *Haplostiche*, *Cassidulina*, *Biloculina*, and *Cornuspira* furnish the rarer species.

D. Stations 37 to 58, *North Atlantic, Bermuda to Nova Scotia and back to Bermuda.*

Station 40.—April 28, 1873. Lat. 34° 51′ N., long. 68° 30′ W. Depth, 2675 fathoms.

Globigerina ooze, containing the common varieties of *Globigerina* and *Pulvinulina*, with *Pullenia*, *Truncatulina*, *Lagena*, *Nonionina* and a few small *Lituolæ*.

Station 45.—May 3, 1873. Lat. 38° 34′ N., long. 72° 10′ W. Depth, 1240 fathoms; bottom temperature, 2°·4 C.; mud.

Grey sandy mud, with a considerable variety of Foraminifera and some Radiolaria, the fauna presenting more northerly features. In addition to *Globigerina* and *Pulvinulina*, the following genera amongst others are conspicuous:—*Pullenia*, *Biloculina*, *Miliolina*, *Lagena*, *Cristellaria*, *Uvigerina*, *Nonionina*, *Gaudryina*, *Verneuilina*, *Bulimina*, and *Virgulina*.

Station 46.—May 6, 1873. Lat. 40° 17′ N., long. 66° 48′ W. Depth, 1350 fathoms; bottom temperature, 2°·3 C.; mud.

Grey mud, with sand and little stones. Rhizopod-fauna very similar to that of Station 45, with the addition of *Haplophragmium scitulum* and *Haplophragmium globigeriniforme*, together with fragments of some of the larger arenaceous types.

Station 47.—May 7, 1873. Lat. 41° 15′ N., long. 65° 45′ W. Depth, 1340 fathoms; mud.

Sandy mud with Rhizopoda of the same general character as the foregoing. Nos. 46 and 47 are in about the latitude of New York.

E. Stations 59 to 83, *North Atlantic—Bermuda to the Azores and Madeira.*

Station 64.—June 20, 1873. Lat. 35° 35′ N., long. 50° 27′ W. Depth, about 2750 fathoms; grey ooze.

Left but little residue after washing: the Foraminifera were those of an ordinary mid-Atlantic Globigerina ooze.

Station 70.—June 26, 1873. Lat. 38° 25′ N., long. 35° 50′ W. Depth, 1675 fathoms; Globigerina ooze.

Containing *Globigerinæ* of all the common varieties, including *Globigerina rubra*, the ordinary pelagic species of *Pulvinulina*, with the addition of *Pulvinulina pauperata* and *Pulvinulina partschiana*; *Pullenia*, *Hastigerina*, and *Sphæroidina*. The remaining genera represented by comparatively few specimens.

Station 73.—June 30, 1873. Lat. 38° 30′ N., long. 31° 14′ W. Depth, 1000 fathoms; bottom temperature, 3°·7 C.; Globigerina ooze.

Washings of dredge; containing many little stones, fragments of shell, coral, and the like. Scarcely so rich in Rhizopoda as the material from Station 70, but presenting a very similar list of species, the principal additions being *Hormosina carpenteri* and some large *Biloculinæ*. There were also a number of Ostracoda and a few Radiolaria.

Station 75.—July 2, 1873. Lat. 38° 37′ N., long. 28° 30′ W. Off the Azores. Depth, 450 fathoms; coral sand.

The Foraminifera chiefly of the following genera:—*Nodosaria*, *Lingulina*, *Cristellaria*, *Globigerina*, *Pulvinulina*, *Discorbina*, *Polytrema*, and *Textularia*; of these *Polytrema* and *Lingulina* are especially fine.

Station 76.—July 3, 1873. Lat. 38° 11′ N., long. 27° 9′ W. Off the Azores. Depth, 900 fathoms; bottom temperature, 4°·2 C.; Globigerina ooze.

Containing small stones, pteropods, and a good deal of coarse stuff. In addition to *Globigerina* and the pelagic *Pulvinulinæ*, the more noteworthy species belong to the genera *Biloculina*, *Miliolina*, *Cristellaria*, *Truncatulina*, *Rupertia*, *Haplophragmium*, *Trochammina*, and *Hormosina*.

Station 78.—July 10, 1873. Lat. 37° 24′ N., long. 25° 13′ W. Depth, 1000 fathoms; Globigerina ooze.

Coarse material very similar in character and contents to the last-named, but richer in the large arenaceous types. This is almost the only locality at which *Astrorhiza granulosa* and *Astrorhiza angulosa* have been observed; and *Rhabdammina discreta*, *Hormosina carpenteri*, and two or three species of *Haplophragmium* are amongst the more abundant forms. One or two specimens of *Polytrema* were also noticed.

F. Stations 84 to 110, *North Atlantic from Madeira, by the Canaries and Cape de Verde Islands, to the Equator, at about long.* 30° *W.*

Station 85.—July 19, 1873. Lat. 28° 42′ N., long. 18° 6′ W. Off Palma, Canary Islands. Depth, 1125 fathoms; volcanic sand.

Resembled very closely the two foregoing samples (Stations 76 and 78), both in the nature of the dredged material and the organisms found in it. *Rhabdammina abyssorum* and *Cyclammina cancellata* may be added to the list of arenaceous species.

Station 93.—July 27, 1873. Off St. Vincent. Depth, 1070 fathoms; mud.

Furnishes a long and interesting list of species. In addition to the *Globigerinæ*, *Pulvinulinæ*, and other ordinary constituents of a Globigerina ooze, the thimbleful of material—for only a sounding was obtained—was especially rich in the genera *Bulimina*, *Cassidulina*, and *Haplophragmium*. The following amongst other rare forms were found in it:—*Cassidulina subglobosa*, *Bulimina contraria*, *Virgulina subsquamosa*, *Textularia quadrilatera*, *Haplophragmium scitulum*, and *Trochammina nitida*.

Station 98.—August 14, 1873. Lat. 9° 21′ N., long. 18° 28′ W. Depth, 1750 fathoms; bottom temperature, 2°·0 C.; Globigerina ooze.

Largely composed of *Pulvinulina menardii*; amongst the *Globigerinæ* are a number of specimens of *Globigerina rubra*. The Arenacea are represented

by *Ammodiscus charoides*, *Webbina clavata*, *Thurammina papillata*, *Haplophragmium globigeriniforme*, *Verneuilina propinqua*, and some of the smaller species of *Hormosina* and *Reophax*. The presence of a few specimens of *Amphistegina* may be noted, as unusual in deep water so far from land. There were in addition a few Ostracoda and Radiolaria.

G. Stations 111 to 142, *South Atlantic from the Equator, about long.* 30° *W., by Pernambuco, Bahia, and the Island of Tristan d'Acunha to the Cape of Good Hope.* (See also Stations 313 to 347.)

Station 111.—August 31, 1873. Lat. 1° 45′ S., long. 30° 58′ W. Depth, 2475 fathoms; bottom temperature, 0°·2 C.; Globigerina ooze.

A yellow mud which left little residue after washing. Rich in Radiolaria, but containing few distinctive Foraminifera. After *Globigerina*, *Pulvinulina*, and *Pullenia*, the genus *Lagena* is perhaps best represented; there were likewise two interesting, neatly built *Miliolæ*, namely, *Miliolina venusta* and *Spiroloculina tenuis*, which are not uncommon in deep water. Arenacea small and rare.

Station 120.—September 9, 1873. Lat. 8° 37′ S., long. 34° 28′ W. Off Pernambuco. Depth, 675 fathoms; mud.

Brown sandy mud, with pteropod shells and some Radiolaria; very rich in arenaceous Foraminifera. Almost every recent variety of *Globigerina*, and all the pelagic *Pulvinulinæ* abound in this material, as well as *Sphæroidina*, *Pullenia*, *Candeina*, and *Hastigerina*. Amongst Arenacea the following are the more important genera:—*Cyclammina*, *Rhabdammina*, *Hyperammina*, *Lituola*, and *Trochammina*. Large specimens of *Nodosaria*, *Lingulina*, and *Biloculina* are also noticeable, together with the following rare species:—*Planispirina sigmoidea*, *Ophthalmidium inconstans*, *Cristellaria variabilis*, and *Gaudryina rugosa*.

Station 122.—September 10, 1873. Lat. 9° 5′ S. to 9° 10′ S., long. 34° 49′ W. to 34° 53′ W. Depth, 350 fathoms; mud.

Brown sandy mud with shell fragments, similar in most respects to No. 120. Very rich in the same sandy types, together with large *Textulariæ* and *Bigenerinæ*; the specimens, however, are generally a good deal worn.

Station 135.—October 18, 1873. Off Nightingale Island, Tristan d'Acunha. Depth, 100 to 150 fathoms; rock and shells.

Not very rich in Foraminifera, the only remarkable form being a wild-growing

variety of *Cristellaria articulata* (Pl. LXIX. figs. 1–4), which is very abundant and of large size. The remaining specimens are for the most part small, and referable to the genera *Globigerina*, *Pulvinulina*, *Truncatulina*, *Anomalina*, *Discorbina*, *Amphistegina*, and *Textularia*.

Station 142.—December 18, 1873. Lat. 35° 4′ S., long. 18° 37′ E. Off the Cape of Good Hope. Depth, 150 fathoms; bottom temperature, 8°·3 C.; sand.

Sand with coral and sponge débris. The Foraminifera, which are a good deal worn, bear a general resemblance to those of a North Atlantic dredging of similar latitude and depth, and in this relation the occurrence of such forms as *Operculina ammonoides*, *Truncatulina refulgens*, *Rotalia orbicularis*, a broken specimen of *Rupertia stabilis*, *Haplophragmium canariense*, and *Astrorhiza arenaria*, is of considerable interest. Amongst the rarer species found, *Uvigerina canariensis* and *Sagrina nodosa* are the most worthy of note.

Station 142 A.—December 1873. Simon's Bay, South Africa. Depth, 15 to 20 fathoms; sand.

Containing shallow-water Foraminifera of common species, and Ostracoda; the former chiefly of the following genera:—*Miliolina*, *Haplophragmium*, *Textularia*, *Lagena*, *Nodosaria*, *Polymorphina*, *Uvigerina*, *Spirillina*, *Rotalia*, *Truncatulina*, and *Polystomella*.

H. Stations 143 to 161, *Southern Ocean, from the Cape of Good Hope by Kerguelen Islands and Heard Island to the Antarctic Circle, and thence to Melbourne.*

Station 144.—December 24, 1873. Lat. 45° 57′ S., long. 34° 39′ E. Depth, 1570 fathoms; bottom temperature, 1°·7 C.; Globigerina ooze.

Chiefly composed of the typical *Globigerina bulloides* and *Globigerina inflata*, with relatively a very small number of *Pulvinulinæ*. A good many arenaceous forms present, but the specimens generally small; amongst them the more interesting are perhaps *Rhizammina algæformis*, *Hyperammina elongata*, and *Reophax cylindrica*. The genera *Miliolina*, *Lagena*, and *Truncatulina* furnish most of the remaining species.

Station 145.—December 26 and 27, 1873. Off Prince Edward Island. Depth, 50 to 150 fathoms; mud.

This material was chiefly made up of the remains of Polyzoa, Crustacea, Annelida, Mollusca, and the like, and was tolerably rich in Ostracoda,

Radiolaria and Foraminifera. It contained a few pelagic *Globigerinæ* and *Pulvinulinæ*, with *Cassidulina crassa*, *Pullenia quinqueloba* and *Anomalina coronata* in greater abundance, as well as the slender and delicate *Articulina funalis*. The specimens of *Pullenia* were remarkable for their variety of colour when first taken out of spirit, the sarcode of some being yellowish, of others brown, pinkish, or olive-green. The remaining species were of no special interest.

Station 146.—December 29, 1873. Lat. 46° 46′ S., long. 45° 31′ E. Depth, 1375 fathoms; bottom temperature, 1°·5 C.; Globigerina ooze.

Greyish white mud with fragments of echinus shell, spines, &c. Like the foregoing, chiefly made up of *Globigerina bulloides* and *Globigerina inflata*. Of the surface *Pulvinulinæ* the comparatively uncommon *Pulvinulina crassa* appears to preponderate in this locality. Arenaceous Foraminifera are almost entirely wanting. The occurrence of two or three specimens of *Clavulina communis* forms perhaps the most interesting feature in the dredging.

Station 149 D.—January 19, 1874. Kerguelen Islands, Balfour Bay, Royal Sound. Depth, 20 to 60 fathoms.

Composed of shallow-water organic remains of all sorts,—algæ, sponges, annelids, molluscan-shells and the like, with but little sand. Foraminifera by no means abundant, and, with the exception of *Discorbina parisiensis*, the specimens of which were particularly fine, and the somewhat rare *Articulina funalis*, all of common littoral species of such genera as *Miliolina*, *Biloculina*, *Truncatulina*, and *Polystomella*. The same material supplied a long list of Ostracoda.

Station 149 E.—January 20, 1874. Kerguelen Islands, Royal Sound. Depth, 28 fathoms.

Mud, made up in like manner of organic débris, with many Ostracoda and Diatomaceæ. The Foraminifera consisted of poor specimens of common littoral and shallow-water species.

Station 149 I.—January 29, 1874. Kerguelen Islands, off Christmas Harbour. Depth, 120 fathoms.

The material brought up in the dredge was a felted mass of siliceous, fibre-like sponge-spicules. Lodged in its meshes were Ostracoda, Foraminifera, and Diatomaceæ. Of the Foraminifera the following are the most characteristic species:—*Pullenia quinqueloba*, *Cassidulina crassa*, *Articulina funalis*,

Ammodiscus charoides, *Ammodiscus shoneanus*, *Ammodiscus gordialis*, *Reophax spiculifera*, *Haplophragmium canariense*, and *Haplophragmium glomeratum*.

Station 150.—February 2, 1874. Lat. 52° 4′ S., long. 71° 22′ E. Between Kerguelen and Heard Islands. Depth, 150 fathoms; bottom temperature, 1°·8 C.; rock.

The dredged material contained a good deal of organic débris of one sort or other, derived from sponges, brittle-stars, corals, &c., with only a limited Rhizopod-fauna. *Globigerinæ* of the small, rounded, starved variety, tolerably abundant, together with *Cassidulina crassa*, a subangular variety of *Uvigerina pygmæa*, *Truncatulina lobatula*, and *Biloculina depressa*. Amongst other microzoa may be mentioned a few Ostracoda and some Radiolaria.

Station 151.—February 7, 1874. Off Heard Island. Depth, 75 fathoms; mud.

Black mud with algæ. As at the previous Station, *Cassidulina crassa*, *Pullenia quinqueloba*, and a subangular variety of *Uvigerina pygmæa* were the prevailing Foraminifera. There were a few specimens of *Articulina funalis*, and the genera *Lagena*, *Bolivina*, *Patellina*, and *Discorbina* were represented amongst others.

Station 153.—February 14, 1874. Lat. 65° 42′ S., long. 79° 49′ E. Ice barrier. Depth, 1675 fathoms; mud.

Fine sandy mud, leaving scarcely any residue after washing; containing Diatomaceæ and abundance of Radiolaria. This sounding is of interest as the most southerly yet obtained, the locality being but little more than a degree outside the Antarctic Circle. The characteristic Foraminifera are *Globigerina dutertrei*, *Haplophragmium latidorsatum*, *Cyclammina pusilla*, and *Clavulina communis*.

Station 155.—February 23, 1874. Lat. 64° 18′ S., long. 94° 47′ E. Ice barrier. Depth, 1300 fathoms; mud.

Light coloured muddy material, similar to the foregoing both in physical characters and microzoic fauna, but with fewer arenaceous Foraminifera, and a corresponding increase in calcareous species.

Station 157.—March 3, 1874. Lat. 53° 55′ S., long. 108° 35′ E. Depth, 1950 fathoms; diatom ooze.

White feathery-looking siliceous material, almost entirely composed of Diatomaceæ and Radiolaria, effervescing but little on treatment with acid.

Foraminifera rare and thin-shelled; belonging to a limited number of species, the most important being *Keramosphæra murrayi*, which has not hitherto been found in any other locality; the rest chiefly *Globigerinæ* of the small, rounded variety, and *Globigerina inflata*, *Rotalia soldanii*, *Cassidulina crassa* and *Cassidulina subglobosa*, *Verneuilina pygmæa*, and *Reophax scorpiurus*.

Station 160.—March 13, 1874. Lat. 42° 42′ S., long. 134° 10′ E. Depth, 2600 fathoms; bottom temperature, 0°·2 C.; red clay.

Reddish brown mud, leaving scarcely any residue after washing. Contains a large number of Radiolaria. The Foraminifera, which are of common Globigerina ooze species, nearly all rotten and disintegrating.

I. Stations 162 to 196, *South Pacific, from Melbourne to Sydney, thence to Wellington, New Zealand, and by Cook Strait and Kermadec Island to Fiji; thence through Torres Strait, and by the Moluccas, to the Equator, at about long.* 126° *E.*

Station 162.—April 2, 1874. Off East Moncœur Island, Bass Strait. Depth, 38 to 40 fathoms; sand.

Coral-sand, with remains of Hydrozoa, Polyzoa, and molluscan shells. Rich in shallow-water types, such as *Miliolina* and *Spiroloculina*, *Textularia*, *Polymorphina*, *Discorbina*, and *Rotalia*. Amongst the rarer species which occur are *Miliolina triquetra*, *Textularia folium*, *Textularia inconspicua*, *Discorbina opercularis*, *Discorbina biconcava*, and *Rotalia clathrata*.

Station 163 B.—April 17, 1874. Port Jackson. Depth, 2 to 10 fathoms.

Sand, with shells and fragments of coral.

Station 163 C.—April 20, 1874. Port Jackson. Depth, 6 fathoms; black muddy sand.

The general character of the Rhizopoda of these two samples is very similar. The Milioline genera are largely represented, together with *Peneroplis*, *Lagena*, *Rotalia*, *Polystomella*, and especially *Discorbina*. A single specimen of *Bulimina williamsoniana* and one of *Polystomella imperatrix* are amongst the rarer species;—the latter is common, and attains fine dimensions at some points on the coast of Tasmania.

Station 164 A.—June 13, 1874. Lat. 34° 13′ S. long. 151° 38′ E. Off Sydney. Depth, 410 fathoms; grey ooze.

The organisms contained in the material from this Station are infiltrated in a very remarkable manner with a siliceous mineral (Glauconite), and by decalcifying with weak acid, perfect casts of the chambers of most of the Foraminifera of a common Globigerina ooze may be obtained. The list of species is a tolerably long one, and contains an admixture of some shallow-water forms, but otherwise presents nothing very distinctive.

Station 166.—June 23, 1874. Lat. 38° 50′ S., long. 169° 20′ E. Off west coast of New Zealand. Depth, 275 fathoms; bottom temperature, 10°·0 C.; Globigerina ooze.

Only a small quantity available for examination, but this yielded a long and interesting catalogue of species. Amongst the more noteworthy of these, considering the habitat, are the following:—*Globigerina rubra*, *Chilostomella ovoidea*, *Ehrenbergina serrata*, *Clavulina communis*, *Clavulina cylindrica*, *Rotalia clathrata*, *Anomalina coronata*, *Frondicularia inæqualis*, and *Ramulina globulifera*. The strictly arenaceous genera are only sparingly represented.

Station 167.—June 24, 1874. Lat. 39° 32′ S., long. 171° 48′ E. West coast of New Zealand. Depth, 150 fathoms; grey ooze.

Leaves but little residue after washing; contains the common pelagic species of *Globigerina* and *Pulvinulina;* a considerable number of *Cristellariæ*, amongst them *Cristellaria tricarinella* and *Cristellaria reniformis;* also various species of *Nodosaria*, *Chilostomella*, *Bulimina*, *Cassidulina*, *Truncatulina*, &c. There is a conspicuous absence of the arenaceous types.

Station 167 A.—Wellington Harbour, New Zealand. Mud from tow-net.

A small quantity of black mud with broken shells; the Foraminifera, chiefly common varieties of *Miliolina*, *Lagena*, *Bulimina*, *Rotalia*, *Nonionina*, and *Polystomella*, present nothing of special interest, except *Rotalia clathrata*, of which the specimens are fine and characteristic.

Station 168.—July 8, 1874. North-east coast of New Zealand. Lat. 40° 28′ S., long. 177° 43′ E. Depth, 1100 fathoms; bottom temperature, 2°·0 C.; grey ooze.

Washings of dredge; consisting chiefly of mud and the arenaceous tubes of annelids (and of Rhizopoda?). The foraminiferal fauna resembles that of a rich northern Globigerina mud, with a large number of arenaceous species. Amongst the more interesting forms are *Pulvinulina pauperata* and

Pulvinulina elegans, *Cristellaria reniformis*, *Haplophragmium scitulum*, *Hormosina normani* (broken), *Ammodiscus tenuis*, and *Rhabdammina linearis*. Some of the arenaceous tubes above alluded to are of considerable size, and may possibly belong to a Rhizopod like *Rhabdammina discreta*.

Station 172.—July 22, 1874. Off Nukualofa, Tongatabu, Friendly Islands. Depth, 18 fathoms; coral.

Foraminifera of the large calcareous types exceedingly abundant, the genus *Orbitolites* supplying a very considerable proportion of the whole. In addition to *Orbitolites complanata* and *Orbitolites marginalis*, the gigantic complex variety *Orbitolites laciniata* appears in great numbers. Of smaller species *Nubecularia divaricata*, *Miliolina reticulata*, *Miliolina alveoliniformis*, and *Miliolina parkeri*, *Hauerina ornatissima*, *Vertebralina insignis*, *Truncatulina echinata*, and *Truncatulina rostrata* are the most notable.

Station 173 A.—July 29, 1874. Off Fiji. 12 fathoms; coral.

Very similar in all respects to the last named. *Orbitolites* in great abundance, and beautifully perfect, with *Operculina*, *Amphistegina*, *Tinoporus*, *Peneroplis*, and *Heterostegina*, the last comparatively rare. There was but little fine material, consequently the list of the smaller species is limited.

Station 174, A. B. C.—August 3, 1874. Lat. 19° 10′ S., long. 178° 10′ E. Off Kandavu, Fiji Islands.

A. Depth, 255 fathoms; Globigerina ooze.

B Depth, 610 fathoms; bottom temperature, 3°·7 C.; Globigerina ooze.

C. Depth, 210 fathoms; sand.

A. and B. were merely soundings, of which a small quantity only has been available for examination. They are essentially Globigerina muds with an admixture of shallow-water Foraminifera, and contain the following species in addition to a considerable list of *Globigerinæ* and *Pulvinulinæ*, namely:—*Cymbalopora bulloides* and *Cymbalopora humilis*, *Chilostomella ovoidea*, *Patellina corrugata*, *Cassidulina calabra* and *Cassidulina bradyi*, *Ehrenbergina serrata*, *Textularia folium* and *Textularia aspera*, *Clavulina communis*, *Haplophragmium scitulum* and *Haplophragmium latidorsatum*.

C. is an exceedingly rich dredging, with the Foraminifera fauna of the deeper coral reefs. The following are some of the more characteristic species:—*Cristellaria cultrata*, *Cristellaria italica*, *Cristellaria siddalliana*, *Cristellaria vortex*, *Cristellaria calcar*, *Cristellaria papillosa*, *Cristellaria*

mamilligera, *Cristellaria echinata*, *Cristellaria gemmata* and *Cristellaria costata*; *Uvigerina schwageri*, *Ramulina globulifera*, *Truncatulina haidingerii* and *Truncatulina culter*, *Pulvinulina procera*, *Verneuilina triquetra*, and *Clavulina parisiensis*. It was from this Station also that the very rare *Cycloclypeus guembelianus* was obtained.

Station 175.—August 12, 1874. Lat. 19° 2′ S., long. 177° 10′ E. Depth, 1350 fathoms; bottom temperature, 1°·8 C.; red clay.

Contained all the common Foraminifera of a Globigerina ooze, the specimens, for the most part, worn and discoloured. There were in addition a few Radiolaria.

Station 177.—August 18, 1874. Lat. 16° 45′ S., long. 168° 5′ E. New Hebrides. Depth, 125 fathoms.

Dark-coloured sand and stones. Contained a few *Globigerinæ* and pelagic *Pulvinulinæ*, together with a large number of shallow-water species, amongst which those of the genera *Lagena*, *Nodosaria*, *Cristellaria*, *Textularia*, and *Bolivina* are prominent. The following are some of the less common forms:—*Carpenteria monticularis*, *Pulvinulina schreibersii*, *Discorbina tabernacularis*, *Truncatulina margaritifera*, *Bulimina williamsoniana*, *Bolivina reticulata* and *Bolivina hantkeniana*.

Station 179.—August 21, 1874. Lat. 15° 58′ S., long. 160° 48′ E. Depth, 2325 fathoms; red clay.

A fine mud, leaving scarcely any residue after washing. The Foraminifera are chiefly those of a Globigerina ooze, with the addition of a considerable variety of *Lagenæ*, and a very few specimens of the smaller arenaceous forms. *Ehrenbergina hystrix* occurs in this material, and a single somewhat doubtful specimen of *Pulvinulina favus* was met with.

Station 185.—August 31, 1874. Lat. 11° 35′ S., long. 144° 3′ E. Off Raine Island, Torres Strait. Depth, 155 fathoms; sand.

In respect of Rhizopoda, this is probably the richest dredging made during the whole Challenger expedition, the list from the single locality having just about the same number of species as the entire British foraminiferal fauna, that is to say, nearly two hundred in all. Amongst the many very rare forms are the following:—*Lagena spiralis*, *Lagena hertwigii*, and *Lagena schulzeana*; *Cristellaria gemmata* and *Cristellaria tricarinella*; *Sagrina limbata*, *Pulvinulina procera* and *Pulvinulina schreibersii*; *Truncatulina præcincta*, *Rupertia crassitesta*, *Textularia crispata*, *Textularia folium*, and

Textularia transversaria; Pavonina flabelliformis, Chrysalidina dimorpha, Spiroplecta annectens, Cassidulina calabra, Cornuspira sulcata and *Cornuspira carinata.*

STATION 185 A.—September 7, 1874. Torres Strait, Cape York. Depth, 3 to 11 fathoms.

Sand and stones, with fragments of shells, coral, and the like, all much worn and broken. Foraminifera poor; the genera *Operculina, Amphistegina, Alveolina, Miliolina, Polystomella,* and *Rotalia* furnishing the principal species.

STATION 186.—September 8, 1874. Flinders Passage and off Wednesday Island, Torres Strait. Depth, 7 to 8 fathoms; coral sand.

The specimens from these dredgings were also a good deal worn. The porcellanous genera furnish the more interesting species, of which are *Miliolina rupertiana, Miliolina, reticulata* and *Miliolina agglutinans; Hauerina compressa, Hauerina circinata,* and *Hauerina ornatissima.* A few worn specimens of *Discorbina vesicularis* were noticed, but the principal part of the Foraminifera are the varieties of the shallow-water tropical types *Alveolina, Peneroplis, Orbitolites, Amphistegina, Heterostegina, Operculina, Calcarina,* and *Tinoporus.*

STATION 187.—September 9, 1874. Lat. 10° 36′ S., long. 141° 55′ E. Depth, 6 fathoms; coral sand.

STATION 187 A.—September 9, 1874. Off Booby Island, Torres Strait. Depth, 8 fathoms; coral sand.

The material from these two Stations closely resembles that from the two immediately preceding, both in physical characters and in the prevailing organisms. The Foraminifera are for the most part of the shallow-water genera just enumerated. Amongst the less common forms *Clavulina angularis* and *Clavulina parisiensis,* and the varieties of *Miliolina* and *Hauerina,* already mentioned as occurring at Station 186, are the most noticeable.

STATION 188.—September 10, 1874. Lat. 9° 59′ S., long. 139° 42′ E. Depth, 28 fathoms; mud.

Sandy mud, with stones and fragments of coral, molluscan shells, Echini, and the like. Rhizopod-fauna derived chiefly from the Milioline genera and the following, namely, *Peneroplis, Clavulina, Bolivina, Pulvinulina, Rotalia,* and *Polystomella,* the rare species being *Rotalia papillosa* and an allied form, and *Polystomella subnodosa.*

Station 189.—September 11, 1874. Lat. 9° 36′ S., long. 137° 50′ E. Depth, 25 to 29 fathoms; mud.

Sandy mud, with shells and fragments of Echini. Foraminifera practically identical with those at Station 188. In both localities *Miliolina reticulata* is abundant, and the specimens are sculptured in a singularly beautiful manner, as shown in Pl. IX. figs. 2, 3. The material appeared rich in Ostracoda.

Station 191.—September 23, 1874. Lat. 5° 41′ S., long. 134° 4′ E. Off Arrou Islands. Depth, 800 fathoms; bottom temperature, 3°·9 C.; mud.

Bluish muddy clay, leaving scarcely any residue after washing. Contained a few Foraminifera, of Globigerina ooze species, with the addition of *Uvigerinæ* and *Buliminæ*, and one or two of the smaller arenaceous forms.

Station 191 A.—September 24, 1874. Lat. 5° 26′ S., long. 133° 19′ E. Off Ki Islands. Depth, 580 fathoms; bottom temperature 4°·9 C.; mud.

A black unctuous mud, of which very little remained after washing; very rich in Foraminifera, and containing a few Ostracoda and Radiolaria. In addition to the common pelagic species of *Globigerina* and *Pulvinulina*, the very rare *Globigerina digitata* was there found in great perfection. In the same locality occur *Frondicularia inæqualis* and *Bulimina contraria*. The genera *Bulimina*, *Uvigerina*, and *Lagena* are all largely represented.

Station 192.—September 26, 1874. Lat. 5° 42′ S., long. 132° 25′ E. Noon. Off Ki Islands. Depth, 129 fathoms; mud.

Sandy mud, with fragments of coral, even richer in Foraminifera than the foregoing. Of rare species the following are noteworthy:—*Frondicularia robusta*, *Frondicularia interrupta*, *Frondicularia spathulata*, *Frondicularia inæqualis*, *Polymorphina seguenzana*, *Ramulina globulifera*, *Ehrenbergina serrata*, *Carpenteria monticularis*, and *Spiroplecta annectens*.

Station 195.—October 3, 1874. Lat. 4° 21′ S., long. 129° 7′ E. Banda Sea. Depth, 1425 fathoms; bottom temperature, 3°·0 C.; grey ooze.

The material examined was the "washings of trawl," which consisted of mud, with many black grains, and contained large numbers of arenaceous Foraminifera. Of this group the following genera furnish the bulk of the specimens:—*Cyclammina*, *Haplophragmium*, *Reophax*, *Hormosina*, *Webbina*, *Rhabdammina*, and *Hyperammina*. A single specimen of *Bathysiphon filiformis* was also obtained. The calcareous Foraminifera present no remarkable features.

Station 195 A.—October 6, 1874. Off Amboyna. Depth, 15 to 20 fathoms.

Micaceous sand, with shells, coral and organic débris. The Foraminifera consisted almost entirely of fine large *Operculinæ;* other coral-reef types, such as *Polytrema*, *Amphistegina*, and *Heterostegina*, were present in smaller numbers, together with a few inconspicuous deep-water forms.

J. Stations 197 to 205 A.—*Celebes Sea and China Sea,—from the Equator, about long.* 126° *E., by the Philippine Islands to Hong Kong.*

Station 201.—October 26, 1874. Lat. 7° 3′ N., long. 121° 48′ E. Off Zamboanga, Philippine Islands. Depth, 102 fathoms ; stones and gravel.

A single stone covered with the most beautiful adherent organisms is the sole material record of this dredging. The parasitic Foraminifera that had made their home upon it belong to the following species:—*Carpenteria monticularis, Polytrema miniaceum, Polytrema album, Planorbulina larvata, Truncatulina lobatula, Placopsilina cenomana, Hyperammina vagans,* and *Valvulina conica.* Amongst these are the specimens of *Carpenteria* which are figured in Pl. XCIX. figs. 1–5, and of *Polytrema album* in Pl. CI. figs. 2, 3.

Station 202.—October 27, 1874. Lat. 8° 32′ N., long. 121° 55′ E. East of the Philippines. Depth, 2550 fathoms ; bottom temperature, 10°·2 C. ; grey ooze.

Mud, which left but little residue after washing ; rich in Radiolaria, but containing scarcely any Foraminifera beyond a few *Globigerinæ* and *Buliminæ.*

Station 204 A.—November 11, 1874. Manilla Harbour. Depth, 4 fathoms ; anchor mud.

Black sticky mud, which left little after washing ; Rhizopoda confined to a few thin-shelled *Rotaliæ* and *Miliolinæ.*

Station 205 A.—Hong Kong Harbour. Depth, 7 fathoms ; anchor mud.

Sandy mud, with broken shells and numerous Ostracoda. Foraminifera of common shallow-water species:—*Rotalia* and *Polystomella* (very fine), *Lagena, Discorbina, Pulvinulina, Nonionina, Textularia, Bolivina,* and the various Milioline genera furnishing the more prominent forms.

K. Stations 206 to 220.—*From Hong Kong by the Philippine Islands to the north coast of Papua, thence north-east by the Admiralty Islands to the Equator at about long.* 147° *E.*

Station 206.—January 8, 1875. Lat. 17° 54′ N., long. 117° 14′ E., China Sea. Depth, 2100 fathoms; bottom temperature, 2°·3 C.; red clay.

Dark-coloured mud, leaving little to examine after the impalpable portion was washed out; containing many Radiolaria. Foraminifera few and poor, of common Globigerina ooze species, with nothing requiring note or comment.

Station 209.—January 22, 1875. Lat. 10° 10′ N., long. 123° 55′ E. Philippine Islands. Depth, 95 to 100 fathoms; bottom temperature, 21°·7 C.; mud.

Only a small quantity of the material from this locality was available for microscopic examination, and it presented a somewhat unusual mixture of deep and shallow-water forms. In company with the pelagic types, *Globigerina*, *Pulvinulina*, *Sphæroidina* and the like, were *Orbitolites*, *Cymbalopora*, *Chilostomella*, and *Polystomella*. Amongst the less common species may be noted *Textularia carinata*, *Truncatulina præcincta*, *Truncatulina margaritifera*, *Clavulina parisiensis*, *Vaginulina patens*, and *Cristellaria calcar*.

Station 214.—February 10, 1875. Lat. 4° 33′ N., long. 127° 6′ E. Depth, 500 fathoms; bottom temperature, 5°·3 C.; Globigerina ooze.

Brown mud, with stones, fragments of Echini and sponges. Except a few specimens of *Candeina nitida*, the Foraminifera were all of common Globigerina ooze species.

Station 217 A.—Humboldt Bay, Papua. Depth, 37 fathoms; anchor mud.

Black clay, leaving scarcely any residue after washing, but affording nevertheless an extended catalogue of shallow-water forms. Of these the following are some of the less common:—*Nubecularia tibia*, *Nubecularia divaricata*, *Miliolina triquetra*, *Miliolina costata*, *Miliolina cultrata*, and *Miliolina angustissima*; *Sagrina virgula*, *Uvigerina interrupta*, *Bulimina williamsoniana*, *Truncatulina præcincta*, *Truncatulina rostrata*, and *Truncatulina ammonoides*, and *Discorbina vesicularis*.

Station 218.—March 1, 1875. Lat. 2° 33′ S., long. 144° 4′ E. North of Papua. Depth, 1070 fathoms; bottom temperature, 2°·1 C.; Globigerina ooze.

The material dredged at this Station resembles in almost every respect that obtained from similar depth at many points in the North Atlantic. It is particularly rich in Arenacea, of which *Rhabdamminæ* are the most conspicuous, but the genera *Reophax*, *Haplophragmium*, *Cyclammina*,

Ammodiscus, *Hormosina*, *Webbina*, and *Hyperammina* are all represented. Perhaps the only species present that would suggest a southern habitat is *Clavulina communis*.

Station 218 A.—March 7, 1875. Nares Harbour, Admiralty Islands. Depth, 16 to 25 fathoms.

Coral-sand and nullipore. In addition to the tropical shallow-water types, such as *Alveolina*, *Amphistegina*, *Calcarina*, *Operculina*, and *Heterostegina*, the material from this dredging abounds in rare varieties of the Milioline genera; but perhaps the most interesting of all the organisms it contains are certain adherent Foraminifera which make their home on the fragments of coral and nullipore, of which it is largely composed. These species are *Carpenteria utricularis*, *Sagenella frondescens*, and *Bdelloidina aggregata*,—of which the figured specimens are all from this locality,—*Planorbulina larvata*, *Polytrema miniaceum*, and *Polytrema album*.

Station 219 A.—March 10, 1875. Nares Harbour, Admiralty Islands. Depth, 17 fathoms; anchor mud.

Somewhat muddy coral-sand, with *Orbitolites* and the other ordinary shallow-water tropical types. This, like the dredging last described, is exceedingly rich in the less common Milioline forms, and also in the genera *Textularia*, *Bolivina*, *Spirillina*, and *Truncatulina*. The following are some of the more interesting species from the list:—*Textularia concava*, *Textularia siphonifera*, *Textularia folium*, and *Textularia inconspicua*; *Bolivina tortuosa*, *Bolivina limbata*, and *Bolivina schwageriana*; *Cassidulina* (*Orthoplecta*) *clavata*, *Spirillina obconica*, *Spirillina inæqualis*, and *Spirillina limbata*; *Truncatulina echinata*, *Truncatulina præcincta*, and *Truncatulina reticulata*; *Rupertia crassitesta*, *Sagrina* (?) *tesselata* and *Sagrina virgula*.

L. Stations 221 to 236.—*North Pacific, from the Equator, in long.* 147° *E., to Japan.*

Station 224.—March 21, 1875. Lat. 7° 45′ N., long. 144° 20′ E. Depth, 1850 fathoms; bottom temperature, 1°·3 C.; Globigerina ooze.

A white *Globigerina* deposit with a considerable number of Radiolaria, containing also fragments of pumice from the size of a pea to that of a hazel-nut. Many of the specimens of *Globigerina* and its allies and of *Pulvinulina* are of fine dimensions. *Pulvinulina favus*, one of the rarer species of the latter genus, makes its appearance at this locality. The material is characterised by an almost entire absence of *Uvigerinæ* and *Textulariæ*, and the comparative rarity of arenaceous species.

Station 227.—March 27, 1875. Lat. 17° 29′ N., long. 141° 21′ E. Depth, 2475 fathoms ; bottom temperature, 1°·0 C. ; red clay.

Fine mud, leaving scarcely anything after washing. The Foraminifera confined to a few very minute specimens of the smaller arenaceous species and one or two *Cassidulinæ*.

Station 231.—April 9, 1875. Lat. 31° 8′ N., long. 137° 8′ E. Depth, 2250 fathoms ; bottom temperature, 0°·6 C. ; grey ooze.

Fine grey mud, with a considerable variety of Foraminifera, though the specimens are few in number and of very small dimensions individually. The genera represented are *Globigerina*, *Pulvinulina*, *Pullenia*, *Chilostomella*, *Lagena*, *Miliolina*, *Biloculina*, *Haplophragmium*, and *Gaudryina*.

Station 232.—May 12, 1875. Lat. 35° 11′ N., long. 139° 28′ E. South of Japan (Hyalonema ground). Depth, 345 fathoms ; bottom temperature, 5°·0 C. ; sandy mud.

Black mud with annelid tubes, Foraminifera, Radiolaria, and Diatomaceæ. The genus *Globigerina* is tolerably abundant, whilst *Pulvinulinæ*, except *Pulvinulina partschiana*, are comparatively rare. *Bulimina*, *Chilostomella*, *Bolivina*, *Uvigerina*, and *Truncatulina* are all conspicuous types. Amongst the rare species *Allomorphina trigona*, of which two or three specimens were found, and *Textularia quadrilatera* are the most interesting.

Station 233 B.—May 26, 1875. Lat. 34° 20′ N., long. 133° 35′ E. Inland Sea, Japan. Depth, 15 fathoms ; mud.

Black mud, with shell fragments and Holothuriæ, Ostracoda, and some Diatomaceæ. Contained comparatively few Foraminifera, and all of common in-shore types, such as *Rotalia*, *Polystomella*, *Nonionina*, *Miliolina*, and *Bolivina*.

M. Stations 237 to 270.—*North Pacific, from Japan eastward to about long.* 154° *W., thence directly south by the Sandwich Islands to the Equator.*

Station 238.—June 18, 1875. Lat. 35° 18′ N., long. 144° 8′ E. Depth, 3950 fathoms ; bottom temperature, 1°·0 C. ; red clay.

This is the deepest sounding that has come under my notice. The quantity of material available for examination was small, and consisted of dark brown, muddy clay, which was much reduced in bulk by washing. It contained Radiolaria in abundance, but very few Foraminifera. *Miliolæ* were the only

representatives of the calcareous forms, and the shells of these were no longer calcareous, but consisted of a thin film of homogenous silica, unaffected by acids, and iridescent when first taken out of spirit. There were, however, small specimens of a number of arenaceous species in excellent condition, the principal of which are the following:—*Reophax scorpiurus* and *Reophax membranacea*, *Haplophragmium latidorsatum* and *Haplophragmium pseudospirale*, *Trochammina trullissata*, and *Gaudryina siphonella*.

Station 241.—June 23, 1875. Lat. 35° 41′ N., long. 157° 42′ E. Depth, 2300 fathoms; bottom temperature, 1°·1 C.; red clay.

The residue after washing consisted almost exclusively of Radiolaria. The Foraminifera present were mostly referrible to few genera:—*Globigerina*, *Pulvinulina*, *Pullenia*, *Lagena*, and *Polymorphina*, with rare specimens of *Verneuilina spinulosa* and *Reophax difflugiformis*. The *Lagenæ* are remarkable alike for their exceeding minuteness and the variety of form and ornamentation they assume.

Station 242.—June 24, 1875. Lat. 35° 29′ N., long. 161° 52′ E. Depth, 2575 fathoms; bottom temperature, 1°·1 C.; red clay.

A Radiolaria mud, similar in general characters to the last described, and, like it, chiefly interesting in respect to the genus *Lagena*.

Station 244.—June 28, 1875. Lat. 35° 22′ N., long. 169° 53′ E. Depth, 2900 fathoms; bottom temperature, 1°·2 C.; red clay.

The "washings of the trawl," consisting chiefly of little stones and brown mud, yielded few calcareous Rhizopoda, but a great abundance of some of the arenaceous types. The most important of the latter were:—*Hyperammina vagans*, *Pelosina cylindrica*, *Aschemonella catenata*, and *Rhizammina algæformis*; together with *Haplophragmium latidorsatum*, *Haplophragmium globigeriniforme*, and *Reophax nodulosa*, as representatives of the smaller Arenacea.

Station 245.—June 30, 1875. Lat. 36° 23′ N., long. 174° 31′ E. Depth, 2775 fathoms; bottom temperature, 1°·0 C.; red clay.

Residue after washing chiefly Radiolaria and siliceous sponge-spicules; Foraminifera confined to a few thin-shelled *Miliolæ*, and minute Arenacea.

Station 246.—July 2, 1875. Lat. 36° 10′ N., long. 178° 0′ E. Depth, 2050 fathoms; bottom temperature, 1°·3 C.; grey ooze.

The "washings of dredge," which were the subject of examination, consisted chiefly of rounded pieces of pumice, some of them almost covered with *Hyperammina vagans*. The general character of the Rhizopod-fauna was very similar to that of Station 244, abounding in the large sandy types, such as *Hyperammina*, *Pelosina*, and *Aschemonella*, as well as in the smaller species of *Hormosina* and *Reophax*. These, with a few specimens of *Saccammina sphærica*, built up of *Globigerina* shells, together with *Verneuilina propinqua* and two or three varieties of *Haplophragmium*, represented the arenaceous groups. Of calcareous Foraminifera there were comparatively few in this rough material; such as were present were of the common Globigerina ooze species.

Station 253.—July 14, 1875. Lat. 38° 9′ N., long. 156° 25′ W. Depth, 3125 fathoms; bottom temperature, 1°·0 C.; red clay.

Sticky mud, of which the little residue left after washing consisted chiefly of Radiolaria. It contained relatively a good many small arenaceous Foraminifera, such as *Reophax nodulosa* and *Reophax scorpiurus*, *Ammodiscus incertus* and *Ammodiscus gordialis*, *Thurammina papillata*, *Haplophragmium globigeriniforme*, and fragments of *Aschemonella catenata*; together with a few calcareous species. Some of the *Miliolæ* had extremely thin shells, and exhibited the same bluish or iridescent tinge, when freshly taken out of spirit, as the specimens from Station 238, already alluded to.

Station 254.—July 17, 1875. Lat. 35° 13′ N., long. 154° 43′ W. Depth, 3025 fathoms; bottom temperature, 1°·0 C.; red clay.

This sounding was very similar to the foregoing; but the quantity washed was small, and the residue only sufficient to indicate in a general way that the Foraminifera were of much the same character.

Station 256.—July 21, 1875. Lat. 30° 22′ N., long. 154° 56′ W. Depth, 2950 fathoms; bottom temperature, 1°·2 C.; red clay.

The description of the material from Station 253 applies in all essential particulars to this also, except that the number of small arenaceous Foraminifera was not here so large, nor the list of species so long.

Station 260 A.—July 31, 1875. Off Reefs, Honolulu, Sandwich Islands. Depth, 40 fathoms; coral-sand.

This material presented a Rhizopod-fauna rich in the ordinary coral-reef species of *Heterostegina*, *Amphistegina*, *Polytrema*, *Cymbalopora*, *Textularia*, *Orbitolites*, and the various Milioline genera. Amongst the less common

forms it contained were *Alveolina melo, Textularia siphonifera, Chrysalidina dimorpha, Pavonina flabelliformis, Truncatulina echinata,* and *Frondicularia robusta.*

Station 265.—August 25, 1875. Lat. 12° 42′ N., long. 152° 1′ W. Depth, 2900 fathoms; bottom temperature, 0°·8 C.; red clay.

A reddish brown siliceous mud, giving no perceptible effervescence on treatment with acid; containing Radiolaria, sponge-spicules and perforated siliceous flakes, the fragments of a gigantic Diatom. Except two or three *Miliolæ* and as many *Globigerinæ*, no calcareous Foraminifera were met with. Of the Arenacea, *Ammodiscus gordialis* and *Haplophragmium latidorsatum* were the most frequent species, but there were fragments of some others, chiefly of tubular forms like *Hyperammina.*

N. Stations 271 to 298, *South Pacific, from the Equator, about long.* 150° *W., southward through the Low Archipelago, then south-east to Lat.* 40° *S., and east to Valparaiso.*

Station 271.—September 6, 1875. Lat. 0° 33′ S., long. 151° 34′ W. Depth, 2425 fathoms; bottom temperature, 1°·0 C.; Globigerina ooze.

The dredged material might, with almost equal propriety, be called a Radiolaria ooze, from the relative abundance of siliceous Rhizopoda. The larger Foraminifera were chiefly of two species, *Pullenia obliquiloculata* and *Pulvinulina tumida.* All the common varieties of *Globigerina* were present, together with such genera as *Lagena, Nodosaria, Truncatulina,* and *Nonionina;* but perhaps the species most characteristic of the locality were *Pulvinulina favus* and *Ehrenbergina serrata.*

Station 272.—September 8, 1875. Lat. 3° 48′ S., long. 152° 56′ W. Depth, 2600 fathoms; bottom temperature, 1°·0 C.; Radiolaria ooze.

A reddish clay, largely composed of Radiolaria. Foraminifera of very much the same aspect as at the last Station. *Pulvinulina favus* was again prominent, but *Ehrenbergina* was not observed.

Station 276.—September 16, 1875. Lat. 13° 28′ S., long. 149° 30′ W. Depth, 2350 fathoms; bottom temperature, 1°·0 C.; red clay.

Dark reddish brown mud, with pumice and manganese nodules; abundance of siliceous organisms, Radiolaria, sponge-spicules, &c.; containing no very large number of Foraminifera, and chiefly remarkable for the variety and beauty of the *Lagenæ.* For the rest, there was nothing worthy of note except *Pulvinulina favus* and *Reophax difflugiformis.*

Station 279 A.—October 2, 1875. Off Papiete, Tahiti. Depth, 420 fathoms; mud.

Station 279 C.—Same date. Depth, 620 fathoms; mud.

The material obtained from these neighbouring points was much alike, both in physical aspect and organic constituents—a bluish black, sticky mud, which left little residue after washing. The list of Foraminifera obtained in either case was extensive and interesting, indicating a fauna equally removed from a Globigerina ooze on one hand and a tropical shallow-water sand on the other, though possessing many of the species of both. Of comparatively rare forms the following are conspicuous:—*Textularia quadrilatera*, *Bolivina hantkeniana*, *Bolivina karreriana*, *Bolivina nobilis* and *Bolivina porrecta*, *Virgulina subsquamosa*, *Chilostomella ovoidea*, *Allomorphina trigona* (very rare), and *Patellina corrugata*.

Station 280.—October 4, 1875. Lat. 18° 40′ S., long. 149° 52′ W. Depth, 1940 fathoms; bottom temperature, 1°·6 C.; Globigerina ooze.

Clean Foraminifera, with little black stones, but no fine mud. It contains the common varieties of *Globigerina*, *Pulvinulina*, *Sphæroidina*, and *Pullenia*, with *Haplophragmium latidorsatum* in large numbers, *Ehrenbergina hystrix*, *Candeina nitida*, *Uvigerina asperula*, *Pulvinulina favus*, and other interesting species. Amongst the microzoa were also a few Ostracoda and Radiolaria.

Station 283.—October 9, 1875. Lat. 26° 9′ S., long. 145° 17′ W. Depth, 2075 fathoms; bottom temperature, 1°·3 C.; red clay.

A reddish brown mud, of which the residue after washing presented the remains of a Foraminifera-fauna similar to that last described, except that neither *Candeinæ* nor *Ehrenberginæ* were detected in it.

Station 285.—October 14, 1875. Lat. 32° 36′ S., long. 137° 43′ W. Depth, 2375 fathoms; bottom temperature, 1°·0 C.; red clay.

Brownish black mud, with pumice and manganese nodules; fish-teeth, a few Radiolaria, and very few Foraminifera. Of the latter there was little beyond one or two of the smaller arenaceous species, the specimens of which were very delicate and often broken.

Station 286.—October 16, 1875. Lat. 33° 29′ S., long. 133° 22′ W. Depth, 2335 fathoms; bottom temperature, 0°·8 C.; red clay.

A brown manganese mud, precisely like the foregoing, both in physical characters

and organic constituents. It contained a rather larger number of Foraminifera, both of arenaceous and calcareous species, but they represent collectively a very limited fauna.

Station 296.—November 9, 1875. Lat. 38° 6′ S., long. 88° 2′ W. Depth, 1825 fathoms; bottom temperature, 1°·2 C.; red clay.

Light brown mud, which after washing had all the features of a Globigerina ooze. Amongst the more striking species were *Pulvinulina crassa* (very common), *Pulvinulina pauperata* and *Pulvinulina favus*, *Cassidulina subglobosa*, *Verneuilina pygmæa*, *Ehrenbergina serrata*, *Virgulina subdepressa*, *Hormosina normani* (broken), and *Hyperammina ramosa*.

O. Stations 299 to 313, *South Pacific and Magellans Strait. From Valparaiso to the Island of Juan Fernandez, thence southwards amongst the Islands on the west coast of Patagonia, and through Magellans Strait to the South Atlantic.*

Station 299.—December 14, 1875. Lat. 33° 31′ S., long. 74° 43′ W. Depth, 2160 fathoms; bottom temperature, 1°·1 C.; grey mud.

The dredged material consisted almost exclusively of a tubular branching chitino-arenaceous Rhizopod—*Rhizammina algæformis*. A small quantity of mud brought up at the same time yielded a considerable number of interesting sandy species, belonging to the genera *Haplophragmium*, *Reophax*, *Trochammina*, *Hormosina*, and *Rhabdammina*, together with a few calcareous forms.

Station 300.—December 17, 1875. Lat. 33° 42′ S., long. 78° 18′ W. North of Juan Fernandez. Depth, 1375 fathoms; bottom temperature, 1°·5 C.; Globigerina ooze.

Contained a good deal of mud. After *Globigerina* and *Pulvinulina*, the genera most largely represented were *Pullenia*, *Truncatulina*, *Uvigerina*, and *Biloculina*. Of characteristic species, *Cassidulina subglobosa* and *Pulvinulina favus* were the most important; *Bolivina decussata*, *Sagrina virgula*, and *Uvigerina angulosa* are also forms of some interest. Broken specimens of *Rupertia stabilis* and *Ehrenbergina serrata* were noticed. Of the sandy types, *Rhizammina algæformis* alone need be mentioned.

Station 302.—December 28, 1875. Lat. 42° 43′ S., long. 82° 11′ W. Depth, 1450 fathoms; bottom temperature, 1°·5 C.; Globigerina ooze.

A typical *Globigerina* deposit, similar in its prevailing forms to that last named,

but with few of the rarer species. This is the most southerly Station at which *Pulvinulina favus* has been found. *Lagena seminiformis* and *Cassidulina bradyi* are perhaps the most noteworthy species. Amongst the microzoa were a good many Ostracoda and some Radiolaria.

Station 304.—December 31, 1875. Lat. 46° 53′ S., long. 75° 11′ W. Gulf of Penas, west coast of Patagonia. Sounding; depth, 45 fathoms; sand.

Clean, dark-coloured, fine sand, with a poor, starved Rhizopod-fauna. Small specimens of *Pulvinulina karsteni*, a form most at home in the Arctic seas, here make their appearance, together with *Cassidulina parkeriana*, *Cassidulina crassa*, and *Discorbina vilardeboana*.

Station 305.—January 1, 1876. Lat. 47° 48′ S., long. 74° 48′ W. Sounding; depth, 120 fathoms; mud.

This material also presented a sub-arctic list of Foraminifera, and, without information as to the locality might have been supposed to have been dredged on the coast of Norway. The conspicuous forms were *Truncatulina refulgens* and *Truncatulina lobatula*, *Pulvinulina punctulata* and *Pulvinulina karsteni*, with various species of *Lagena*, *Uvigerina*, *Nonionina*, *Bulimina*, and *Cassidulina*. *Ehrenbergina pupa* was perhaps the most notable species met with in its examination.

Station 306.—January 2, 1876. Lat. 48° 18′ S., long. 74° 33′ W. Off Middle Island. Sounding; depth, 345 fathoms; bottom temperature, 7°·6 C.; mud.

Station 306 A.—Same date. In a neighbouring locality. Sounding; depth, 565 fathoms; mud.

The soundings from both these points yielded Foraminifera of the same boreal character as the foregoing, the genera *Bulimina* and *Nonionina* being especially prominent.

Station 307.—January 4, 1876. Lat. 49° 24′ S., long. 74° 23′ W. Sounding; depth, 147 fathoms; bottom temperature, 7°·6 C.; mud.

Station 308.—January 5, 1876. Lat. 50° 10′ S., long. 74° 42′ W. Sounding; depth, 175 fathoms; mud.

Station 309.—January 8, 1876. Lat. 50° 56′ S., long. 74° 15′ W. Sounding; depth, 40 to 140 fathoms; mud.

Station 310.—January 10, 1876. Lat. 51° 30′ S., long. 74° 3′ W. Sarmiento Channel. Sounding; depth, 400 fathoms; bottom temperature, 7°·9 C.; mud.

Station 311.—January 11, 1876. Lat. 52° 50′ S., long. 73° 53′ W. Sounding; depth, 245 fathoms; bottom temperature, 7°·7 C.; mud.

The five Stations last enumerated represent a line of soundings amongst the islands on the west coast of Patagonia. The quantity of material available for examination from each locality was exceedingly small, but it was of the same character throughout, and sufficiently revealed the general aspect of Rhizopod-fauna. The same sub-arctic species prevailed as at the preceding four Stations, with the addition of a varying proportion of some of the smaller Arenacea, such as *Reophax scorpiurus*, *Haplophragmium latidorsatum* and *Haplophragmium canariense*, *Clavulina communis*, *Valvulina fusca*, and an occasional starved specimen of *Cyclammina cancellata*.

Station 313.—January 20, 1876. Lat. 52° 20′ S., long. 68° 0′ W. Magellans Strait. Depth, 55 fathoms; bottom temperature, 8°·8 C.; sand.

Very muddy sand, nearly barren of Foraminifera. Contains only a few *Miliolæ*, *Truncatulinæ*, *Discorbinæ*, and other shallow-water forms, in starved condition.

P. Stations 314 to 347.—*South Atlantic, from Magellans Strait to the Falkland Islands, and thence to Buenos Ayres. From Buenos Ayres eastward to about long.* 13° *W., and then nearly direct north by the Island of Ascension to the Equator at about long.* 14° *W.*

Station 315 A.—February 1, 1876. Stanley Harbour, Falkland Islands. Depth, 6 fathoms.

Black mud, with broken shells. Much richer in Ostracoda than in Foraminifera, which latter consisted chiefly of starved varieties of *Rotalia*, *Polystomella*, *Lagena*, and *Bulimina*. The only species of any particular interest were *Patellina corrugata* and *Bulimina elegantissima*.

Station 317.—February 8, 1876. Lat. 48° 37′ S., long. 55° 17′ W. North of the Falkland Islands. Depth, 1035 fathoms; bottom temperature, 1°·7 C.; hard ground.

The material examined was a small quantity of coarse, shelly sand, with a sprinkling of little black stones. The Foraminifera it contained were for the

most part of the North Atlantic or sub-arctic cold-area type, but with very few arenaceous species. *Globigerina*, *Pulvinulina*, *Truncatulina*, *Pullenia*, *Uvigerina*, and *Textularia*, furnish almost the entire fauna. A few examples of *Rupertia stabilis* and *Cassidulina crassa*, and a single specimen of *Ehrenbergina serrata* were noted.

Station 321.—February 25, 1876. Lat. 35° 2′ S., long. 55° 15′ W.; mouth of the Rio de la Plata. Depth, 13 fathoms; mud.

Fine black mud, leaving scarcely any residue after washing, and revealing a Rhizopod-fauna of brackish or estuarine character. Foraminifera not numerous, the calcareous species thin-shelled. The following are the prominent forms:—various *Miliolæ*, *Polystomella striatopunctata*, *Nonionina turgida*, and *Haplophragmium canariense*.

Station 322.—February 26, 1876. Lat. 35° 20′ S., long. 53° 42′ W. About 60 miles E.S.E. of Lobos Island. Depth, 21 fathoms; shells.

Some mud with broken shells from this Station was carefully examined, in the hope that it would yield brackish-water organisms, but it appeared to contain few organic remains, and no Foraminifera whatever.

Station 323.—February 28, 1876. Lat. 35° 39′ S., long. 50° 47′ W. Depth, 1900 fathoms; bottom temperature, 0°·0 C.; grey mud.

The dredged material consisted of very fine, dark-coloured mud, the residue of which, after washing, was almost entirely composed of arenaceous Rhizopoda, pertaining to the following genera:—*Rhabdammina*, *Hyperammina*, *Aschemonella*, *Psammosphæra*, *Reophax*, *Haplophragmium*, *Placopsilina*, *Cyclammina*, *Ammodiscus*, *Hormosina*, *Webbina*, and *Thurammina*. Of these the more interesting species were *Haplophragmium foliaceum* and *Haplophragmium tenuimargo*, *Reophax guttifera* and *Reophax distans*, *Hormosina ovicula*, *Rhabdammina linearis*, and two dwarf modifications of *Cyclammina*.

Station 324 A.—February 29, 1876. Lat. 36° 9′ S., long. 48° 22′ W. Sounding; depth, 2840 fathoms; bottom temperature, 0°·4 C.; grey mud.

Fine mud, which left scarcely any residue for examination after washing; containing a very few arenaceous Foraminifera, with abundance of Radiolaria.

Station 328.—March 6, 1876. Lat. 37° 38′ S., long. 39° 36′ W. Sounding; depth, 2900 fathoms; bottom temperature, 0°·3 C.; grey mud.

Very similar to the foregoing. The washed residue contained plenty of Radiolaria, but only one or two arenaceous Foraminifera.

Station 332.—March 10, 1876. Lat. 37° 29′ S., long. 27° 31′ W. Depth, 2200 fathoms; bottom temperature, 0°·4 C.; Globigerina ooze. Might with equal propriety be termed "grey mud."

The dredged material was rich in Radiolaria, but the Foraminifera were all of the common Globigerina ooze species.

Station 335.—March 16, 1876. Lat. 32° 24′ S., long. 13° 5′ W. Depth, 1425 fathoms; bottom temperature, 2°·3 C.; Globigerina ooze.

A somewhat muddy Globigerina ooze, with a considerable number of Ostracoda. Contained a large variety of Foraminifera, but comparatively few rare species; amongst the less common may be cited:—*Candeina nitida*, *Spiroloculina acutimargo*, and *Bolivina reticulata*. The sandy forms were poorly represented.

Station 337.—March 19, 1876. Lat. 24° 38′ S., long. 13° 36′ W. Depth, 1240 fathoms; bottom temperature, 2°·5 C.; Globigerina ooze.

The bottom at this locality and at Station 339 furnished interesting examples of what is termed by Mr. Murray "Pteropod ooze" (*vide*, p. 80). The washed material consisted chiefly of Pteropod shells; and the Foraminifera present belonged exclusively to surface species. Amongst the latter are most of the known forms of *Globigerinæ* and of pelagic *Pulvinulinæ*, together with a considerable number of *Hastigerinæ* and *Candeinæ*.

Station 338.—March 21, 1876. Lat. 21° 15′ S., long. 14° 2′ W. Depth, 1990 fathoms; bottom temperature, 1°·8 C.; Globigerina ooze.

A clean Globigerina ooze, with a list of species very similar to No. 335 but with a comparative absence of arenaceous types. *Candeina nitida*, *Hastigerina pelagica*, *Polymorphina longicollis*, *Nodosaria calomorpha*, and a great variety of *Lagenæ*, were the most noteworthy Rhizopoda.

Station 339.—March 23, 1876. Lat. 17° 26′ S., long. 13° 52′ W. Depth, 1415 fathoms; bottom temperature, 2°·5 C.; Globigerina ooze.

More strictly a Pteropod ooze. Yellow pasty mud, the residue of which after washing consisted almost entirely of Pteropod shells and surface Foraminifera. Nearly all the known pelagic species were present, including *Hastigerina pelagica* and *Candeina nitida*. Amongst the bottom forms, the genera *Biloculina*, *Miliolina Ophthalmidium*, *Gaudryina*, *Uvigerina*, and *Truncatulina* were best represented. Of the rarer species *Spiroloculina acutimargo*, *Ophthalmidium inconstans*, *Cassidulina calabra*, and *Truncatulina culter* are the most interesting. Arenaceous types were conspicuously absent.

Station 343 A.—March 30, 1876. Long Beach, Island of Ascension. Shore sand.

A parcel of clean white sand, containing little beyond a few specimens of *Polytrema miniaceum*.

Station 343 B.—April 2, 1876. Off Ascension Island. Depth, 7 fathoms.

Calcareous material, chiefly nullipore, with *Polytrema* as the principal Foraminifer. There were also a few specimens of *Alveolina melo*, one or two of *Miliolina bertheliniana*, some small *Amphisteginæ*, *Textulariæ*, *Orbitolites*, and other shallow-water tropical forms.

Station 344.—April 3, 1876. Off Ascension Island. Depth, 420 fathoms; hard ground.

The material brought up at this locality was sand, with fragments of shell and coral, and the Foraminifera which it contained were of the usual Globigerina ooze species, with *Pullenia obliquiloculata* notably abundant, and *Globigerina rubra* frequent. Except some young specimens of *Carpenteria* (figured in Pl. XCVIII. figs. 13–17), nothing of particular rarity was met with in its examination.

Station 346.—April 6, 1876. Lat. 2° 42′ S., long. 14° 41′ W. Depth, 2350 fathoms; bottom temperature, 0°·4 C.; Globigerina ooze.

Contained a full list of Globigerina ooze species, with scarcely any uncommon forms, except perhaps *Ehrenbergina serrata*, *Virgulina subdepressa*, and *Lagena seminiformis*. The sandy types were represented chiefly by small neat examples of one or two varieties of *Haplophragmium*. Amongst other microzoa were a number of Ostracoda and Radiolaria.

Q. Stations 348 to 354 A.—*North Atlantic, from the Equator about long. 14° W., by the Cape de Verde Islands to the Azores, thence touching at Vigo, to Portsmouth.*

Station 352 A.—April 24, 1876. Off St. Vincent, Cape de Verde Islands. Depth, 11 fathoms.

Dredged calcareous material, chiefly nullipore. Abundance of *Amphisteginæ*, with a few *Pulvinulinæ*, and a number of common shore species.

Station 354 A.—May 21, 1876. Vigo Bay, Spain. Depth, 11 fathoms; anchor mud.

This presented the usual harbour-mud Rhizopod-fauna, with *Rotalia beccarii*, *Polystomella crispa* and *Polystomella striatopunctata*, *Nonionina depressula* and *Nonionina scapha*, *Verneuilina schreibersii* and *Truncatulina lobatula*, as the salient forms.

Surface and Mid-water Collections.

The following notes refer to some of the areas at which gatherings were made by means of the tow-net, and chiefly to those at which the specimens obtained were mounted, or preserved by other means, on the spot. When not otherwise indicated, the net was arranged so as to collect only the organisms inhabiting the surface-layer of the ocean, that is to say, those living at depths not greater than about fifty fathoms; but in many localities the net was lowered much further in order to gather in addition the animals pertaining to the mid-water fauna.

The different sections of the voyage, indicated by capital letters, correspond to the divisions, similarly lettered, of the foregoing list of bottom-dredgings. Very few pelagic Foraminifera have been preserved from the earlier portion of the Challenger cruise, but the North Atlantic is partially represented by gatherings made on the homeward voyage.

F. *North Atlantic; from Madeira by the Canaries and Cape de Verde Islands to the Equator.*

August 13 and 14, 1873, corresponding to Stations 97 and 98. Off the coast of Africa, south of Cape de Verde Islands. Containing *Globigerina bulloides*, *Orbulina universa*, *Pulvinulina menardii*, *Pulvinulina tumida*, and *Pulvinulina canariensis*.

August 16, 1873, corresponding to Station 100. African coast, west of Sierra Leone. Containing *Globigerina bulloides*, *Globigerina rubra*, *Globigerina conglobata*, *Orbulina universa*, *Pullenia obliquiloculata*, and *Pulvinulina menardii*.

August 25, 1873, corresponding to Station 106. Mid-Atlantic near the Equator; surface down to 40 fathoms. Containing *Globigerina bulloides*, *Globigerina dubia*, *Globigerina conglobata*, *Globigerina rubra*, *Globigerina sacculifera*; *Orbulina universa*, *Sphæroidina dehiscens*, *Pullenia obliquiloculata*, *Pulvinulina menardii*, *Pulvinulina canariensis* and *Pulvinulina scitula* (?). "Tow-net at 40 fathoms" furnishes a similar list of organisms.

August 27, 1873, corresponding to Station 108. Mid-Atlantic off St. Paul's Rocks. Containing *Globigerina bulloides, Globigerina dubia, Globigerina conglobata, Globigerina rubra, Globigerina sacculifera; Orbulina universa, Hastigerina pelagica, Sphæroidina dehiscens, Pullenia obliquiloculata, Pulvinulina menardii* and var. *fimbriata, Pulvinulina tumida* and *Pulvinulina micheliniana.*

G. *South Atlantic.* No pelagic Rhizopoda preserved on the outward voyage; see Section P.

H. *Indian Ocean, from the Cape of Good Hope south-west by Kerguelen and Heard Islands to the Antarctic Circle, and thence to Melbourne.*

February 14, 1874, corresponding to Station 153. Antarctic ice-barrier. Surface down to 60 and 100 fathoms. Containing *Globigerina bulloides,* running into *Globigerina dutertrei.*

I. *South Pacific:—Melbourne to Sydney, New Zealand, Fiji, the Moluccas, and the Equator at about long.* 126° *E.*

June 14, 1874, corresponding to Station 164 B. Off Sydney. Containing *Globigerina bulloides, Globigerina dubia, Globigerina inflata; Orbulina universa, Pulvinulina canariensis, Pulvinulina crassa,* and *Pulvinulina micheliniana.*

June 15, 1874, corresponding to Station 164 C. East of Australia. Containing *Pulvinulina canariensis, Pulvinulina crassa,* and *Pulvinulina micheliniana.*

June 17, 1874, corresponding to Station 165. Between Sydney and Wellington. Containing *Globigerina bulloides, Globigerina dubia, Globigerina æquilateralis, Globigerina inflata, Orbulina universa, Pulvinulina canariensis, Pulvinulina crassa,* and *Pulvinulina micheliniana.* Amongst these were a few dead and empty shells of bottom species.

August 11 and 12, 1874, corresponding to Station 175. Off Kandavu, Fiji Islands. Containing *Globigerina bulloides, Orbulina universa,* together with some dead empty shells of bottom species.

August 25 and 26, 1874, corresponding to Station 181. North-east of Australia. Containing *Globigerina bulloides, Globigerina conglobata, Globigerina æquilateralis, Globigerina dubia,* and *Orbulina universa.*

J. *Celebes Sea and China Sea:—from the Equator by the Philippine Islands to Hong Kong and*

K. *From Hong Kong by the Philippine Islands to the north coast of Papua, and thence by the Admiralty Islands to the Equator, about long.* 147° *E.*

November 12, 1874, corresponding to Station 205. Off Philippines. Containing *Globigerina bulloides, Candeina nitida* and *Cymbalopora bulloides.*

"Off Zamboanga, Philippines,"—*Cymbalopora bulloides.*

"Off Tablas, Philippines,"—*Globigerina bulloides, Globigerina æquilateralis,* and *Orbulina universa.*

December 11, 1874. Off Philippines. Containing *Globigerina bulloides, Globigerina æquilateralis, Hastigerina pelagica, Candeina nitida,* and *Pulvinulina menardii.*

January 9, 1875, corresponding to Station 206. China Sea, off Luzon, Philippines. Containing *Globigerina bulloides,* fine spinous specimens; *Globigerina sacculifera, Globigerina conglobata, Orbulina universa,* and *Hastigerina pelagica,* together with a single specimen of *Chilostomella ovoidea.*

January 1875. Sulu Sea. Containing *Globigerina bulloides, Orbulina universa,* and *Pulvinulina menardii,* the latter of large size.

February 12, 1875, corresponding to Station 215. Western Pacific between Papua and the Philippines. Containing *Globigerina bulloides, Globigerina æquilateralis, Globigerina conglobata, Pullenia obliquiloculata, Pulvinulina menardii,* and *Pulvinulina canariensis.*

February 1875. Western Pacific. Containing *Globigerina bulloides, Globigerina dubia* (?), *Globigerina rubra, Globigerina æquilateralis, Globigerina sacculifera, Globigerina conglobata, Hastigerina pelagica, Pullenia obliquiloculata,* and *Pulvinulina menardii.*

February 1875. North of Papua. Containing a few very small *Globigerina bulloides* and some large spinous *Globigerina conglobata.*

L. *Western Pacific; from Papua to Japan.*

March 1875. North of Admiralty Islands. Containing *Globigerina bulloides*, *Globigerina conglobata*, and *Globigerina sacculifera*, all in the spinous condition, the last named being of unusually fine dimensions, and fragments of *Hastigerina pelagica*.

M. *North Pacific; from Japan eastward to about long.* 154° *W., and directly south by the Sandwich Islands to the Equator.*

June 17, 1875, corresponding to Station 237. Off Japan. Containing *Globigerina bulloides*, *Globigerina dubia*, *Globigerina rubra*, *Globigerina conglobata*; *Orbulina universa*, *Hastigerina pelagica*, *Pullenia obliquiloculata*, and *Pulvinulina menardii*.

June 19, 1875, corresponding to Station 239. Containing *Orbulina universa* and *Hastigerina pelagica*.

June 21, 1875, corresponding to Station 240. Containing *Globigerina dubia* and *Globigerina inflata*.

June 24, 1875, corresponding to Station 242. Containing *Globigerina bulloides* and *Orbulina universa*.

June 26, 1875, corresponding to Station 243. Deep net. Containing *Globigerina dubia*, thick-shelled specimens, and *Orbulina universa*.

June 28, 1875, corresponding to Station 244. Containing *Globigerina dubia* as the prominent form, the specimens of good size and well-marked; also *Globigerina bulloides*, *Globigerina inflata*, and *Orbulina universa*.

June 30, 1875, corresponding to Station 245. Containing *Globigerina bulloides*, *Globigerina dubia*, and *Globigerina rubra*, many of the shells empty; also some empty tests of arenaceous Foraminifera, and some suspended sand.

July 5, 1875, corresponding to Station 248. Containing *Globigerina bulloides* and *Orbulina universa*.

July 12, 1875, corresponding to Station 252. Containing *Orbulina universa*.

July 17, 1875, corresponding to Station 254. Containing very spinous specimens of *Orbulina universa* and *Hastigerina pelagica.*

July 19, 1875, corresponding to Station 255. Containing *Hastigerina pelagica* and *Orbulina universa.*

July 21, 1875, corresponding to Station 256. Containing *Globigerina bulloides, Orbulina universa, Hastigerina pelagica, Pulvinulina micheliniana,* and *Candeina nitida.*

July 27 to August 2, 1875, corresponding to Station 260. Near the Honolulu Reefs. Containing *Cymbalopora bulloides.*

August 20, 1875, corresponding to Station 262. Containing *Globigerina bulloides, Globigerina sacculifera, Orbulina universa, Hastigerina pelagica,* and *Pulvinulina menardii.*

August 24, 1875, corresponding to Station 265. Containing *Hastigerina pelagica.*

August 31 and September 1, 1875, between Stations 268 and 269. Off Hilo, Tahiti; surface. Containing *Globigerina bulloides, Globigerina dubia, Globigerina æquilateralis, Globigerina conglobata, Orbulina universa,* and *Pullenia obliquiloculata.*

September 2, 1875, corresponding to Station 269. Tow-net down to 20 fathoms. Containing *Globigerina bulloides, Globigerina æquilateralis,* and *Pullenia obliquiloculata,* the two latter represented by thick-shelled specimens.

September 4, 1875, corresponding to Station 270. Just north of the Equator; surface. Containing *Globigerina bulloides, Globigerina dubia, Globigerina æquilateralis, Globigerina conglobata, Globigerina sacculifera, Orbulina universa, Hastigerina pelagica, Pullenia obliquiloculata* (very abundant), and *Pulvinulina menardii.*

N. *South Pacific; from the Equator, south and east, by the Low Archipelago to Valparaiso.*

September 6, 1875, corresponding to Station 271. Tow-net, at a depth of 200 fathoms. Containing *Globigerina bulloides, Globigerina conglobata* (thick-shelled), *Globigerina æquilateralis, Orbulina universa,* and *Pulvinulina menardii.*

"Tow-net on dredge-line at 2425 fathoms," contained spinous specimens of *Globigerina bulloides*, together with *Globigerina æquilateralis* and *Pulvinulina menardii*, the chambers filled with sarcode.

September 8, 1875, corresponding to Station 272. Containing *Globigerina bulloides*, *Globigerina æquilateralis*, *Globigerina conglobata*, and *Pulvinulina menardii*.

September 11, 1875, corresponding to Station 274. Containing *Globigerina bulloides*, *Orbulina universa*, *Pullenia obliquiloculata*, and *Pulvinulina menardii*.

October 19, 1875, corresponding to Station 287. Containing *Globigerina bulloides* and small *Pulvinulinæ* (*P. crassa* and *P. canariensis*?).

October 21, 1875, corresponding to Station 288. Containing small obscure *Pulvinulinæ*.

October 27, 1875, corresponding to Station 291. Tow-net, at a depth of 60 fathoms. Containing *Hastigerina pelagica* and *Pulvinulina crassa* (poor).

October 29, 1875, corresponding to Station 292. Surface. Containing *Globigerina bulloides*, and poor specimens of *Pulvinulina crassa* and *Pulvinulina canariensis*.

November 3, 1875, corresponding to Station 294. Surface down to 200 fathoms. Containing *Pulvinulina canariensis*, *Pulvinulina crassa*, and *Pulvinulina micheliniana*.

November 11, 1875, corresponding to Station 297. Containing *Hastigerina pelagica*.

November 17, 1875, corresponding to Station 298. Off Valparaiso. Tow-net at 200 fathoms. Containing *Hastigerina pelagica*, *Orbulina universa*, *Pulvinulina canariensis* and *Pulvinulina crassa*.

O. *South Pacific from Juan Fernandez down the west coast of Patagonia, and through Magellans Strait.*

December 14, 1875, corresponding to Station 299. Off Valparaiso. Surface to 20 fathoms. Containing *Globigerina bulloides*, *Globigerina dubia*, and *Orbulina universa*.

December 16, 1875, near Station 300, north of Juan Fernandez. Tow-net at 200 fathoms. Containing *Globigerina bulloides*, *Globigerina dubia*, and very thick-shelled specimens of *Orbulina universa*.

December 28, 1875, corresponding to Station 302. Surface. Containing *Globigerina bulloides*, *Globigerina inflata*, *Globigerina dubia*, *Orbulina universa*, *Pulvinulina menardii*, and var. *fimbriata*, *Pulvinulina canariensis*, and a broken specimen of *Sphæroidina dehiscens*.

"Tow-net down to 40 fathoms" presented a similar but less extensive fauna.

December 30, 1875, corresponding to Station 303. Surface to 30 fathoms. Containing small specimens of *Globigerina bulloides*, *Orbulina universa*, *Pulvinulina menardii* and *Pulvinulina canariensis*.

P. *South Atlantic, from Magellans Strait to the Falkland Islands, Buenos Ayres, and Ascension Island, touching the Equator about long.* 14° *W.*

February 11, 1876, corresponding to Station 318. Near the surface. Containing poor, thin-shelled *Globigerina bulloides*.

March 3 and 5, 1876, corresponding to Stations 326–328. Containing *Globigerina bulloides*, *Hastigerina pelagica*, *Pullenia obliquiloculata*, and *Pulvinulina menardii*.

March 6, 1876, corresponding to Station 328. Tow-net at weights. Containing *Globigerina bulloides*, *Pulvinulina crassa*, *Pulvinulina micheliniana*, and a specimen of *Lagena lævigata*; chiefly bottom shells.

March 13, 1876, corresponding to Station 333. Surface. Containing *Globigerina bulloides*, *Pullenia obliquiloculata*, and *Pulvinulina micheliniana*.

March 16, 1876, corresponding to Station 335. North of Tristan d'Acunha. Surface. Containing *Globigerina bulloides*, *Globigerina conglobata*, *Orbulina universa*, and *Candeina nitida*.

March 19, 1876, corresponding to Station 337. Tow-net at dredge. Containing *Pulvinulina micheliniana*, *Pulvinulina menardii*, *Pulvinulina tumida*, *Sphæroidina dehiscens* (?), *Candeina nitida*, &c. Specimens mostly with very thick shells; some with sarcode, others empty.

March 21, 1876, corresponding to Station 338. Containing *Pulvinulina menardii*.

March 27, 1876, corresponding to Station 343. Off Ascension. Surface. Containing *Globigerina bulloides*, with fine spines, *Globigerina rubra*, *Globigerina sacculifera*, *Orbulina universa*, and *Pulvinulina menardii*.

April 4, 1876, corresponding to Station 345. Containing *Globigerina bulloides*, *Globigerina rubra*, *Globigerina sacculifera*, *Orbulina universa*, *Pulvinulina menardii* and *Pulvinulina scitula* (?).

April 6, 1876, corresponding to Station 346. Containing *Globigerina bulloides*, *Globigerina inflata*, *Globigerina rubra*, *Orbulina universa*, and *Pulvinulina menardii*.

April 7, 1876, corresponding to Station 347. Under the Equator. Containing *Globigerina bulloides*, *Globigerina rubra*, *Orbulina universa*, *Hastigerina pelagica*, and *Pulvinulina menardii*.

Q. *North Atlantic, from the Equator to the Cape de Verde Islands, Azores, Vigo Bay, and Portsmouth.*

April 9, 1876, corresponding to Stations 348 and 102. Surface. Containing *Globigerina bulloides*, *Orbulina universa*, *Hastigerina pelagica*, and *Pulvinulina menardii*.

"Tow-net down to 200 fathoms" contained some additional species, namely, *Globigerina dubia*, *Globigerina rubra*, and *Pulvinulina canariensis*.

April 10, 1876, corresponding to Station 349. Off the coast of Africa. Surface. Containing *Globigerina bulloides*, *Globigerina æquilateralis*, *Globigerina conglobata*, *Globigerina sacculifera* (large spinous specimens), *Orbulina universa*, *Hastigerina pelagica*, *Sphæroidina dehiscens*, *Pullenia obliquiloculata*, and *Pulvinulina menardii*.

April 11, 1876, corresponding to Station 350. Off the coast of Africa. Containing *Globigerina bulloides*, *Globigerina æquilateralis*, *Globigerina conglobata*, *Globigerina sacculifera*, and *Pulvinulina menardii*.

April 12, 1876, corresponding to Station 351. Off the coast of Africa. Containing *Globigerina bulloides*, *Globigerina sacculifera*, *Globigerina dubia*, *Orbulina universa*, and *Pulvinulina menardii*.

April 13, 1876, corresponding to Station 352. Off the coast of Africa. Surface. Containing *Globigerina bulloides*, *Globigerina dubia*, *Globigerina rubra* (poor), *Orbulina universa*, *Hastigerina pelagica*, and *Pulvinulina menardii*.

April 29, 1876. North of Cape de Verde Islands. Surface. Containing *Globigerina bulloides* and *Orbulina universa.*

May 3, 1876, corresponding to Station 353. Containing *Orbulina universa* and *Hastigerina pelagica.*

II. "Porcupine" Expedition.

The cruises of H.M.S. "Porcupine," in the summer of 1869, under the direction of Dr. Carpenter, Professor C. Wyville Thomson, and Dr Gwyn Jeffreys, have furnished material representing the sea-bottom of three distinct areas of the North Atlantic. Unfortunately only a small proportion of the dredgings which were obtained have been found available for the purposes of the present memoir, but the following have been worked out with moderate completeness :—

1st Cruise.—*West and North-West of Ireland.*

Dredging was conducted at thirty-two Stations, from twelve of which samples of the sea-bottom have been examined, and the Rhizopoda determined. They are referrible to an area lying between lat. 51° 42′ *and* 56° 44′ *N., and between long.* 10° 56′ *and* 15° 24′ *W., as follows :—*

No. (A). "Off Valentia.[1] Lat. 51° 42′ N., long. 11° 21′ W. Depth, 112 fathoms." Clean, fine sand. The most noticeable Foraminifera were *Uvigerina pygmæa, Cassidulina lævigata, Bulimina marginata, Bigenerina nodosaria,* and *Operculina ammonoides.* Amongst rare British species were the following :— *Bulimina subteres, Cassidulina bradyi, Chilostomella ovoidea, Nonionina orbicularis,* and *Technitella legumen. Globigerinæ* were present, but not in large number, and the pelagic species of *Pulvinulina* were confined to one or two examples of *Pulvinulina micheliniana.*

No. 1. Lat 51° 51′ N., long 11° 50′ W. Depth, 370 fathoms; surface temperature, 54°·2 Fahr. (12°·3 C.); bottom temperature, 49° Fahr. (9°·4 C.). Muddy sand, with a typical Rhizopod-fauna, of which the salient genera were *Cassidulina, Uvigerina, Bulimina, Bigenerina, Truncatulina,* and the

[1] This batch of material was sent to me amongst a number of "Porcupine" dredgings, by my friend the Rev. A. M. Norman, and it was worked out under the supposition that it belonged to the "Porcupine" series. But I have learned, since the above was written, that it was obtained by Dr. Gwyn Jeffreys on his dredging excursion in the yacht "Osprey," in 1870. Nevertheless, as the results help materially to complete the record of the area embraced in the 1st Cruise, it has been retained in the list.

weaker forms of *Operculina* and *Haplophragmium*. There were also a number of *Globigerinæ*.

No. 6. Lat. 52° 25′ N., long. 11° 40′ W. Depth, 90 fathoms; surface temperature, 54° Fahr. (12°·2 C.); bottom temperature, 50° Fahr. (10° C.).

Muddy sand, with pebbles. General aspect of the Rhizopoda very similar to No. 1, with the addition of *Lagena*, *Bolivina*, and *Nonionina* to the conspicuous genera.

No. 11. Lat. 53° 24′ N., long. 15° 24′ W. Depth, 1630 fathoms; no record of temperature.

Sand, with fragments of echinus shells, spines, &c. *Uvigerina*, *Truncatulina*, *Bulimina*, *Cassidulina*, and *Operculina* in great abundance; *Globigerina* common, together with a few pelagic *Pulvinulinæ*.

No. 14. Lat. 53° 49′ N., long. 13° 15′ W. Depth, 173 fathoms; surface temperature, 53°·2 Fahr. (11°·8 C.); bottom temperature, 49°·6 Fahr. (9°·8 C.).

Grey, muddy sand, similar in general character to No. 11, and containing Foraminifera of the same genera.

No. 15. Lat. 54° 5′ N., long. 12° 17′ W. Depth, 422 fathoms; surface temperature, 52°·2 Fahr. (11°·2 C.); bottom temperature, 47° Fahr. (8°·3 C.).

Rough sand and stones, with fragments of Echini and Pteropods. Foraminifera comparatively rare, much worn and broken, belonging to the common northern types, such as *Truncatulina*, *Uvigerina*, and *Biloculina*.

No. 17. Lat. 54° 28′ N., long. 11° 44′ W. Depth, 1230 fathoms; surface temperature, 53°·2 Fahr. (11°·8 C.); bottom temperature, 37°·8 Fahr. (3°·2 C.).

Fine greasy mud, with little stones and pebbles. The finer silt had been washed out of this before it reached me. The material examined was coarse and sandy, and contained *Globigerinæ*, with a few pelagic *Pulvinulinæ*, examples of *Haplophragmium*, *Hyperammina*, *Saccammina*, *Psammosphæra*, *Rhabdammina*, and other arenaceous types; also specimens of *Biloculina*, *Truncatulina*, *Uvigerina*, *Operculina*, and *Cassidulina*.

No. 18. Lat. 54° 15′ N., long. 11° 9′ W. Depth, 183 fathoms; surface temperature, 53°·2 Fahr. (11°·8 C.); bottom temperature, 49°·4 Fahr. (9°·6 C.).

Fine grey sand, with a good many *Globigerinæ*, and a few pelagic *Pulvinulinæ*. The prominent Foraminifera belonged to the following genera:—*Bulimina*, *Cassidulina*, *Bigenerina*, *Lagena*, *Uvigerina*, *Nonionina*, and *Operculina*.

No. 19. Lat. 54° 53′ N., long. 10° 56′ W. Depth, 1360 fathoms; surface temperature, 54°·8 Fahr. (12°·6 C.); bottom temperature, 37°·4 Fahr. (3° C.).

Fine Globigerina ooze, with a good many pelagic *Pulvinulinæ*, the other conspicuous genera being *Bulimina*, *Virgulina*, *Cassidulina*, *Lagena*, and *Truncatulina*. It contained also a considerable number of Radiolaria.

No. 20. Lat. 55° 11′ N., long. 11° 31′ W. Depth, 1443 fathoms; surface temperature, 55°·5 Fahr. (13° C.); bottom temperature, 37° Fahr. (2°·8 C.).

Fine white Globigerina ooze, with a few Radiolaria, leaving very little residue after washing. The salient Foraminifera were of the genera *Globigerina*, *Pulvinulina*, *Truncatulina*, *Biloculina*, *Miliolina*, and *Haplophragmium*.

No. 23. Lat. 56° 7′ N., long. 14° 19′ W. Depth, 630 fathoms; surface temperature, 57°·3 Fahr. (14° C.); bottom temperature, 43°·5 Fahr. (6°·4 C.).

Labelled "siftings from the sieves." A coarse fibrous-looking mass of arenaceous Rhizopods, sponge-spicules, young sponges, echinus spines, molluscan shells, &c. Amongst the more striking Foraminifera the genera *Sorosphæra*, *Pelosina*, *Hyperammina*, *Marsipella*, *Cyclammina*, *Rhabdammina*, *Haplophragmium*, *Biloculina*, *Cristellaria*, *Uvigerina*, and *Globigerina* were conspicuous.

No. 28. Lat. 56° 44′ N., long. 12° 52′ W. Depth, 1215 fathoms; surface temperature, 57°·6 Fahr. (14°·2 C.); bottom temperature, 37°·1 Fahr. (2°·8 C.).

Labelled "siftings from the sieves:" coarse sandy material, from which the finer portions had been separated by washing; containing *Globigerinæ* and some pelagic *Pulvinulinæ*, with large *Biloculinæ*, *Rhabdammina cornuta*, *Gaudryina pupoides*, *Gaudryina baccata*, and *Virgulina schreibersiana* as prominent forms. There were also a few Radiolaria. It was in the coarser material from this Station that the finest specimens of *Pilulina jeffreysii* were obtained by Dr. Carpenter.

2nd Cruise.—*South and South-West of Ireland.*

Dredging is recorded at thirteen Stations, of which samples from four only have been examined for the present Report. These pertain to the limited region lying between lat. 47° 38′ *and* 49° 12′ *N., and between long.* 10° 57′ *and* 12° 52′ *W.*

No. 35. Lat. 49° 7′ N., long. 10° 57′ W. Depth, 96 fathoms; surface temperature, 63°·4 Fahr. (17°·8 C.); bottom temperature, 51°·3 Fahr. (10°·7 C.).

Fine light grey sand, with large numbers of Foraminifera. Salient genera, *Bulimina*, *Bolivina*, *Cassidulina*, *Lagena*, *Uvigerina*, and *Globigerina*, together with the little northern form of *Operculina*.

No. 36. Lat. 48° 50′ N., long. 11° 9′ W. Depth, 725 fathoms; surface temperature, 64° Fahr. (17°·8 C.); bottom temperature, 43°·9 Fahr. (6°·6 C.).

Coarse brown, sandy gravel, with broken echinus spines and molluscan shells, but chiefly remarkable for the enormous numbers of large thick-shelled *Orbulinæ* which it contained. The genera of Foraminifera best represented were *Globigerina*, *Orbulina*, *Pulvinulina*, *Truncatulina*, *Anomalina*, *Bulimina*, *Glandulina*, *Operculina*, *Miliolina*, *Webbina*, *Haplophragmium*, and *Cyclammina*.

No. 37. Lat. 47° 38′ N., long. 12° 8′ W. Depth, 2435 fathoms; surface temperature, 65°·6 Fahr. (18°·6 C.); bottom temperature, 36°·5 Fahr. (2°·5 C.).

Globigerina ooze, the Foraminifera chiefly *Globigerinæ* and *Orbulinæ*, and pelagic species of *Pulvinulina;* the arenaceous types represented by two forms of *Haplophragmium* which were tolerably abundant, *Reophax scorpiurus*, *Reophax dentaliniformis* and *Reophax difflugiformis*, and fragments of *Rhizammina algæformis*.

No. 42. Lat. 49° 12′ N., long. 12° 52′ W. Depth, 862 fathoms; surface temperature, 62°·6 Fahr. (17° C.); bottom temperature, 39°·7 Fahr. (4°·3 C.).

Orbulina ooze; a grey mud, consisting in very large proportion of thick-shelled *Orbulinæ*. The prevalence of this type is even more striking than in No. 36, though the individual specimens scarcely attain the same dimensions. Beyond the genera *Globigerina*, *Pulvinulina*, and *Truncatulina*, there is little that is noteworthy, though the material furnishes a tolerably long list of species.

3rd Cruise.—*Faröe Channel.*

On this voyage bottom-dredgings were taken at between fifty and sixty Stations, of which reliable samples from only eight or nine have been preserved. Of these, seven are from mid-channel, between the north of Scotland and the Faröe Islands, directly west of Shetland; the eighth is from two localities in comparatively shallow water east of Shetland. Some interesting material from the west coast of Scotland, off the Isle of Skye, has been included in the series for want of a better place.

Attention may be drawn to the fact that Nos. 47, 50, and 51 *show a high bottom temperature, whilst* Nos. 57 *and* 77 *represent a cold area.*

No. 47. Lat. 59° 34′ N., long. 7° 18′ W. Depth, 542 fathoms; surface temperature, 54° Fahr. (12°·2 C.); bottom temperature, 43°·8 Fahr. (6°·5 C.). Corresponding very nearly in position with the "Knight-Errant" Stations 4, 6, 7.

Sandy mud, richer in arenaceous than in calcareous Rhizopoda; containing also one or two small sponges, fragments of brittle-stars, and a few Ostracoda and Radiolaria. Of the Rhizopods the more notable forms were *Astrorhiza arenaria, Marsipella elongata, Planispirina celata, Uvigerina pygmæa,* and *Nonionina umbilicatula,* with a fair number of *Globigerinæ* and a few *Pulvinulinæ.*

No. 50. Lat. 59° 54′ N., long. 7° 52′ W. Depth, 355 fathoms; surface temperature, 52°·6 Fahr. (11°·4 C.); bottom temperature, 46°·2 Fahr. (7°·9 C.).

Brownish sand, not rich in organisms of any sort; the Foraminifera principally belonging to the genera *Globigerina, Uvigerina, Truncatulina,* and *Nonionina.*

No. 51. Lat. 60° 6′ N., long. 8° 14′ W. Depth, 440 fathoms; surface temperature, 51°·6 Fahr. (10°·9 C.); bottom temperature, 42° Fahr. (6°·5 C.). Near the dividing line between the "warm" and "cold" areas.

Sand, with a considerable number of *Globigerinæ,* some of them of the small arctic variety, and *Pulvinulinæ;* but chiefly remarkable as the only locality in which the large arenaceous type *Botellina* has hitherto been found. Other sandy forms, such as *Haplophragmium latidorsatum* and *Planispirina celata,* are common in the dredged material, together with a long list of calcareous species.

No. 57. Lat. 60° 14′ N., long. 6° 17′ W. Depth, 632 fathoms; surface temperature, 52° Fahr. (11°·1 C.); bottom temperature, 30°·5 Fahr. (—0°·8 C.). Position between "Knight-Errant" Stations 2 and 8.

Coarse sand, with a characteristic cold-area Rhizopod-fauna. *Globigerinæ* moderately common, and chiefly of the small arctic variety. *Pulvinulina karsteni,* the specimens very fine, but not abundant; *Rupertia stabilis, Truncatulina lobatula, Haplophragmium latidorsatum,* and *Reophax scorpiurus,* all present in large numbers.

No. 67. Lat. 60° 32′ N., long. 0° 29′ W. Depth, 64 fathoms; surface temperature, 51°·9 Fahr. (11° C.); bottom temperature, 49°·1 Fahr. (9°·5 C.).

No. 68. Lat. 60° 23′ N., long. 0° 33′ E. Depth, 75 fathoms; surface temperature, 52°·5 Fahr. (11°·4 C.); bottom temperature, 44° Fahr. (6°·6 C.).

Mixed material from two adjacent dredgings east of Shetland, consisting of muddy sand, with large numbers of sponge-spicules. The list of Foraminifera includes all the common Shetland species. A few Radiolaria were also met with.

No. 77. Lat. 60° 34′ N., long. 4° 40′ W. Depth, 560 fathoms; surface temperature, 50°·9 Fahr. (10°·5 C.); bottom temperature, 29°·8 Fahr. (—1°·5 C.).

Brown mud, with sand and small stones and sponge débris; Rhizopod-fauna of the cold-area type, very similar to No. 57.

No. 78. Lat. 60° 14′ N., long. 4° 30′ W. Depth, 290 fathoms; surface temperature, 52°·2 Fahr. (11°·2 C.); bottom temperature, 41°·5 Fahr. (5°·3 C.).

Grey shelly sand, full of *Anomalina coronata*, *Truncatulina refulgens* and *Truncatulina lobatula;* but containing comparatively few *Globigerinæ*, and no pelagic *Pulvinulinæ*.

No. 84. Lat. 59° 34′ N., long. 6° 34′ W. Depth, 155 fathoms; surface temperature, 54°·3 Fahr. (12°·4 C.); bottom temperature, 49°·1 Fahr. (9°·5 C.).

Fine grey sand, containing a good many Foraminifera and Ostracoda; of the former the following are the more conspicuous genera:—*Globigerina*, *Pulvinulina*, *Truncatulina*, *Discorbina*, *Uvigerina*, *Cassidulina*, and *Spiroloculina*.

No. (AA). Off Loch Scavaig, Skye; 45 to 60 fathoms.

Shelly sand, with the Rhizopod-fauna characteristic of the laminarian and coralline zones of the west coast of Scotland. The list of species is largely furnished by the following genera:—*Biloculina*, *Miliolina*, *Spiroloculina*, *Lagena*, *Discorbina*, *Truncatulina*, *Rotalia*, *Bulimina*, *Nonionina*, and *Operculina*.

III. "Knight Errant" Expedition.

In the summer of 1880, H.M. hired ship "Knight Errant" was placed at the disposal of Sir C. Wyville Thomson, for the further exploration of the channel lying between the north of Scotland and the Faröe Islands. This ground was partially investigated in 1869, on the third cruise of the "Porcupine," and the indications then obtained of the

close proximity of two areas with widely different bottom temperature, were considered of sufficient importance to render the further elucidation of the physical and biological conditions of the channel desirable.[1]

Six of the bottom-dredgings procured on the cruise of the "Knight Errant" have been examined, of which four, namely, Stations 1, 4, 6 and 7 represent the warm area, and may be associated with Nos. 47, 50, and 51 of the "Porcupine" series; whilst the remainder, namely, Stations 2 and 8, are from the cold region, of which the "Porcupine" material from Nos. 57 and 77 also furnishes examples.

Station 1.—July 27, 1880. Lat. 60° 4′ N., long. 7° 31′ W. Depth, 305 fathoms; bottom temperature, 47°·1 Fahr. (8°·4 C.); surface, 54°·8 Fahr. (12°·6 C.).

Station 4.—August 10. Lat. 59° 33′ N., long. 7° 14′ W. Depth, 555 fathoms; bottom temperature, 45°·4 Fahr. (7°·4 C.); surface, 57° Fahr. (13°·9 C.).

Stations 6 and 7.—August 12. Lat. 59° 37′ N., long. 7° 19′ W. Depth, 530 fathoms; bottom temperature 45°·9 Fahr. (7°·7 C.); surface, 56°·6 Fahr. (13°·7 C.).

The sand and mud from the warm bottoms above enumerated contained Rhizopoda of the large arenaceous types, such as *Saccammina*, *Astrorhiza*, *Rhabdammina*, *Jaculella*, *Marsipella*, and *Hyperammina;* and amongst calcareous forms, *Pullenia* and *Sphæroidina*, with abundance of *Globigerina bulloides* and *Globigerina inflata*.

Station 2.—July 29. Lat. 60° 29′ N., long. 8° 19′ W. Depth, 375 fathoms; bottom temperature, 31° Fahr. (—0°·56 C.); surface, 53° Fahr. (11°·7 C.).

Station 8.—August 17. Lat. 60° 3′ N., long. 5° 51′ W. Depth, 540 fathoms; bottom temperature, 29°·2 Fahr. (—1°·56 C.); surface, 56°·5 (13°·6 C.).

In the dredged material from the cold area the larger arenaceous Rhizopoda, *Astrorhizidæ*, are almost completely replaced by *Lituolidæ*. *Cassidulina lævigata* and *Pullenia sphæroides* are prominent species, and the genus *Cornuspira* is represented by a few specimens of gigantic size. A large proportion of the *Globigerinæ* are of the small thick-shelled arctic variety, *Globigerina borealis*.

Pelagic Fauna.

Gatherings were made by means of the tow-net at various depths from the actual surface down to thirty-five fathoms, on nine different days between July 27th and August

[1] The detailed report of the cruise of the "Knight Errant," by Staff-Commander Tizard, R.N., and Mr. John Murray, assisted by various naturalists, appears in the *Proceedings of the Royal Society of Edinburgh*, 1882, vol. xi. pp. 638–720.

12th. The Foraminifera collected vary but little over the whole area. The *Globigerinæ* are all referrible to *Globigerina bulloides*, *Globigerina inflata*, and *Orbulina universa*. The specimens are small and thin-shelled; those of *Globigerina* are non-spinous, whilst the *Orbulinæ* are sometimes armed with very short delicate spines. No specimens of *Globigerina borealis*, and no *Pulvinulinæ* occur in any of the surface-mountings.

In the summer of 1882 a further investigation of the Faröe Channel was carried out in H.M.S. "Triton," and it is worthy of remark that the most prominent surface Foraminifer obtained by Mr. Murray on that occasion was *Hastigerina pelagica*, which was not only exceedingly abundant in many of the tow-net gatherings, but was represented by specimens of large size and great beauty. On the previous expedition this species was only met with in the shape of a few dead shells in the bottom dredgings from the warm area.

IV. Arctic Seas.

The British North-Polar Expedition of 1875–6, under the command of Capt. Sir G. S. Nares, and the Austro-Hungarian Expedition of 1872–4, directed by Lieuts. Weyprecht and Payer, have put us in the possession of soundings, which, together with some material previously worked out by Messrs. Parker and Jones, afford an excellent basis for a knowledge of the Arctic Rhizopod-fauna. The results of the examination of these various soundings have already been published, so that a summary of their general characters is all that is needful in this place.

British North-Polar Expedition, 1875–6.[1]

Samples of the sea-bottom were brought from twenty-four localities, pertaining to three tolerably distinct areas, namely—1, Baffin's Bay and Smith Sound; 2, Hall Basin; and 3, the region north of Robeson Channel.

1. *Baffin's Bay and Smith Sound.* Sixteen soundings between lat. 77° 15′ and 79° 45′ N., at various depths up to 220 fathoms, but chiefly less than 80 fathoms; the material composed of sand and mud, with small rounded stones and fragments of molluscan shells. Most of the samples contained a few Ostracoda and some Diatomaceæ in addition to Foraminifera. The following were the more prominent species of Foraminifera:—*Cassidulina lævigata* and *Cassidulina crassa*, *Virgulina schreibersiana*, *Truncatulina lobatula*, *Pulvinulina karsteni*, two or three species of *Nonionina* (notably *Nonionina*

[1] On the Reticularian and Radiolarian Rhizopoda of the North-Polar Expedition of 1875–6. *Ann. and Mag. Nat. Hist.*, 1878, ser. 5, vol. i. p. 425, pls. xx., xxi.

scapha), *Polystomella striatopunctata* and *Polystomella arctica*, and *Globigerina bulloides* var. *borealis*.

2. *Hall Basin* (*Discovery Bay*). Lat. 81° 41′ N. Two soundings, in 23 fathoms and 25 fathoms respectively. The Rhizopoda were scarce and minute, principally *Cassidulinæ*, other genera represented by very few examples.

3. *North of Robeson Channel*, various localities, chiefly near the winter quarters of the "Alert." In all seven samples were obtained between lat. 82° 8′ and 83° 19′ N., some of which were glacial muds from the shore, the remainder material brought up with the sounding line. That from the highest latitude, taken from a depth of 72 fathoms (the most northerly sounding hitherto made), indicated a sea-bottom rich alike in Foraminifera, Radiolaria, and Diatomaceæ. The remainder were for the most part poor in Rhizopoda, the genera *Cassidulina*, *Nonionina*, and *Polystomella* being best represented. Most of the samples contained a few Ostracoda.

Austro-Hungarian North-Polar Expedition.[1]

The object of the Austro-Hungarian North-Polar Expedition was to explore that part of the Arctic Ocean lying directly north of the continent of Europe, taking the islands of Novaya Zemlya as a starting-point. The material obtained by Lieuts. Weyprecht and Payer comprised sixteen soundings, which may be referred to two distinct areas, six of them to Barents Sea, on the west and north-west coast of Novaya Zemlya, the remaining ten to a region much further north, namely, the shores of Franz-Josef Land.

To these may be added a small series of soundings made in the summer of 1879, by Capt. A. H. Markham, in the area lying immediately south of the foregoing, that is to say, on the south-western shores of Novaya Zemlya, and in the Matyushin Shar, which complete the somewhat scanty ground-work of our knowledge of the microzoa of the eastern polar seas.

4. *West and North-West Coast of Novaya Zemlya*, between lat. 74° and 77° N. Six soundings at no great distance from the coast-line; depth, from 55 fathoms to 219 fathoms. The Rhizopod-fauna included fifty-four species, the genera *Lagena*, *Cassidulina*, and *Nonionina* being most conspicuously represented. The following forms are abundant, both on the coast of Novaya Zemlya and on the shores of Franz-Josef Land:—*Reophax difflugiformis*, *Reophax scorpiurus*, *Haplophragmium nanum*, *Cassidulina lævigata*, *Cassidulina crassa*, *Globigerina borealis*, *Truncatulina lobatula*, *Pulvinulina karsteni*, and *Polystomella striatopunctata*. Of the species common in these soundings, but not found in the more northern area, *Nonionina scapha* is the most important.

[1] Henry B. Bady, Ueber einige arktische Tiefsee-Foraminiferen gesammelt während der österreichisch-ungarischen Nordpol-Expedition in den Jahren 1872–1874. *Denkschr. d. math.-naturw. Cl. d. k. Akad. d. Wiss.*, vol. xliii. p. 91, pls. i. ii. Also, On some Arctic Foraminifera, &c., *Ann. and Mag. Nat. Hist.*, ser. 5, vol. viii. p. 394, pl. xxi.

5. *Franz-Josef Land*, between lat. 79° and 80° N. Ten soundings at various points along the coast, at depths from 89 fathoms to 145 fathoms. Contained forty-one species of Foraminifera, of which *Saccammina sphærica* and *Reophax nodulosa* were the most important of those not found in the southern area. The smaller arenaceous types were also abundant.

6. *Matyushin Shar and South-Western Coast of Novaya Zemlya*, about lat. 73° N. Seven soundings in all, of which four were from the shallow water of the Matyushin Shar (10 to 15 fathoms). They yielded twenty-two species of Foraminifera, of which *Miliolina agglutinans*, *Hippocrepina indivisa*, *Reophax arctica*, *Trochammina nitida*, *Verneuilina polystropha*, and *Discorbina wrightii* were the most noteworthy. The remaining soundings were from points to the west of the southern portion of Novaya Zemlya, at depths of 30 to 90 fathoms. In these cases the amount of material obtained was very small, and only two additional species resulted from its examination.

DESCRIPTION OF GENERA AND SPECIES.

Family I. GROMIDÆ.

The Gromidæ, as generally defined, are Reticularian Rhizopods, with an imperforate chitinous investment. The investment is either in the condition of a thin pellicle or skin adhering closely to the body of the animal, or, more commonly, forms a distinct test, which the animal may or may not completely fill. The investment or test is normally homogeneous, and is either hyaline, yellowish, or of light brown colour. In rare instances the exterior is encrusted with sand-grains or other foreign matter. The general aperture, when single, is central and axial, or nearly so; when there are two mouths they occupy the opposite poles of the test.

The classification of the naked and chitinous Rhizopoda into *Lobosa*, *Filosa*, and *Reticularia*, according to the characters of their extended pseudopodia, is convenient, and perhaps the best that can be devised with our present limited knowledge; but the relationship of some of the Filose types to the Reticularian is so close as to suggest that the distinction is only one of degree.

In the Synopsis of this family only the distinctly Reticularian genera have been retained; that is to say, those in which the pseudopodia take the form of long, delicate, much-branched sarcode filaments, with ragged and irregular edges, inosculating in places, and very mobile—the transparent matter being loaded with granules which are carried along in more or less evident currents.

The number of genera of chitinous Rhizopods that can be included amongst the Gromidæ with this restriction is at present only five. Of these, *Lieberkuehnia* has a flexible investment adhering closely to the body of the animal, and constantly changing form. *Gromia* and *Mikrogromia* have ovate chitinous tests, differing from each other in little except size—true tests, of which the cavity is not always filled with sarcode. In the genus *Diaphoropodon* the chitinous investment is strengthened by the incorporation of foreign bodies; and, in addition to the long reticulated pseudopodia issuing from the general aperture, there are numberless delicate, filose extensions, short, hyaline, and of nearly equal length, springing from amongst the extraneous bodies encrusting the surface of the test. These four genera are characterised by a single aperture; there

remains one, *Shepheardella*, in which the test consists of a long, more or less flattened cylinder, with an aperture at each end.

It has been suggested by Claus[1] that certain naked sarcode organisms, with long reticulated pseudopodia, *Protogenes primordialis* and others, classed by Haeckel amongst the *Monera*, are true Rhizopods, and that they have more in common with the *Gromidæ* than with the naked Lobose types (*Amœbæa*)—in other words, that they should be regarded as Foraminifera without tests. Probably the *Biomyxa vagans* of Leidy,[2] which has been provisionally placed by its discoverer amongst the *Gromidæ*, is an organism of the same class.

The *Gromidæ* inhabit both salt water and fresh; *Gromia oviformis* and *Gromia dujardinii*, *Lieberkuehnia wageneri*, and *Shepheardella tæniformis* are marine forms found amongst the algæ of shore-pools or otherwise in shallow water. The Challenger collections have yielded no specimens that can with any degree of certainty be assigned to the group. One or two examples of a minute, flask-shaped, chitinous Rhizopod, with broad phialine neck, have been met with amongst the surface gatherings, but the dead tests possess no characters by which their particular affinities can be determined.

The nearest allies of the *Gromidæ* are to be found amongst the *Porcellanea*. In the *Miliolidæ*, the chitinous test is replaced by calcareous deposit, forming a compact imperforate shell; and it is interesting to note that in brackish water, where the proportion of mineral constituents is relatively small, the tests not merely of the *Miliolinæ*, but also of certain species of arenaceous Foraminifera, are often distinctly chitinous and to some extent flexible. There is little except the comparatively larger size of the specimens to distinguish some of the *Astrorhizidæ*, which have membranous tests coated with mud or loose sand (*Pelosina*, for example), from such forms as *Diaphoropodon*; and in one or two genera of the same group short filose extensions of the sarcode springing from the superficial coatings, similar to those which have been noticed in the latter genus, have also been observed.

Family II. MILIOLIDÆ.

The family Miliolidæ is coextensive with Dr. Carpenter's *Miliolida*, with Von Reuss's *Porenlose Foraminiferen*, and with Professor Rupert Jones's *Imperforata vel Porcellana*.

The salient peculiarity of the test throughout the group is accurately characterised by the word porcellanous. In the adult condition the typical shell is smooth, even-textured, and opaque-white; in young specimens, opalescent and translucent; and whether young or old always imperforate.

Its minute structure, as seen when fragments of very young specimens or thin sections of older ones, mounted in Canada balsam, are viewed by transmitted light, is peculiar

[1] Grundzüge der Zoologie, 4th ed. (1880), vol. i. p. 172.

[2] Fresh-water Rhizopods of North America, p. 281.

and cannot be mistaken. The filmy shell or section is never really transparent, however thin; and it has a uniform yellowish or light brown tint, very distinct from the nearly colourless perforate structure exhibited under similar circumstances by the vitreous types.

There are, however, numerous modifications of the typical structure, some of which are hereditary and characteristic of species, whilst others depend in part at least upon external influences. The most important of these arise from the tendency evinced under certain conditions to incorporate sand with the calcareous matter of the shell-wall, and the construction in such cases of a composite or arenaceous test, in place of the normal homogeneous shell. In some species (*Nubecularia lucifuga*, Pl. I. fig. 12, &c., *Miliolina agglutinans*, *Miliolina crassatina*, and *Miliolina triquetra*, Pl. VIII. figs. 5–10) very coarse sand-grains are so employed, and the resulting test is indistinguishable in external texture from the rougher *Lituolæ;* in others (*Planispirina celata*, Pl. VIII. figs. 1, 2) a uniform fine sand is the material selected, and the exterior corresponds more nearly with that of the *Trochamminæ*. Nevertheless in all cases, however thick the sandy incrustation, there is a distinct, imperforate, calcareous shell, of the typical porcellanous structure underneath, immediately surrounding the animal. This may be easily traced in either the transverse or longitudinal section of the test. In the sandy forms the mouth is usually free from incrustation, and is encircled by a smooth, white, shelly rim.

In brackish water, where the supply of earthy salts in solution is smaller than in the open sea, the chemical and physical characters of the shells of such species as survive the changed conditions are considerably modified. They become by degrees less calcareous as the water grows less saline, until eventually a point is reached at which the investment is little more than a chitinous or horny membrane, strengthened by the incorporation of minute siliceous grains, but containing so little carbonate of lime that it is scarcely altered by treatment with acids.[1]

A still more remarkable modification occurs in specimens from the abyssal depths of the North Pacific explored during the Challenger cruise. A few *Miliolæ*, from soundings taken at a depth of 3950 fathoms (about four miles and a half), with somewhat inflated segments, scarcely distinguishable in form from young thin-shelled specimens of a common littoral species, were found to be unaffected by treatment with acids, and upon further examination it became apparent that the normal calcareous shell had given place to a delicate, homogeneous, siliceous investment. Whilst immersed in fluid the shell-wall had the appearance of a nearly transparent film, and when dried was at first somewhat iridescent. The parietes of some of the specimens were so thin that they collapsed on drying, but the stronger shells retained their form, and became white and more or less opaque by exposure to the air.

Of the essentially imperforate nature of the shell throughout the Family there is no

[1] *Miliolina* (*Quinqueloculina*) *fusca*. H. B. Brady, On Brackish-water Foraminifera. *Ann. and Mag. Nat. Hist.*, 1870, ser. 4, vol. vi. p 286, pl. xi. fig. 2.

room for doubt. In a few species of *Miliolina* the exterior is punctate or pitted (*Miliolina rupertiana*, Pl. VII. figs. 7–12, and in certain fossils, *e.g.*, *Miliolina saxorum*); but thin sections of the test show conclusively that the perforate appearance is due to superficial depressions of uniform depth, only penetrating about half the thickness of the shell-wall. Similar punctations may be observed in the genera *Peneroplis* and *Orbiculina* (Pl. XIII. fig. 23, and Pl. XIV. fig. 13), sometimes occurring on the exterior and sometimes on the interior surface of the test, but their superficial character has been fully demonstrated by Dr. Carpenter.[1]

The inter-relationship of the various generic types of the *Miliolidæ* is easily traced. The sub-family Nubeculariné comprises only a few simple and very variable forms, which in some respects stand apart from the rest of the group. The test of *Squamulina* consists of a single adherent chamber, with an aperture on the convex surface; whilst the polythalamous *Nubecularia* is connected with *Peneroplis* by its more regular spiral forms, and with *Miliolina* by its least regular free varieties.

But for the remainder of the Family, the genus *Cornuspira*, the test of which consists of a non-septate tube coiled in one plane, may be taken as the starting-point. A shell like that of *Cornuspira*, with constrictions at two opposite points of each convolution, that is to say, with each convolution divided into two segments, is the type of the genus *Spiroloculina*, and from this the other strictly Milioline genera differ chiefly in such particulars as the mutual disposition of the segments, their obliquity and degree of curvature, and the extent to which they overlap each other. The genus *Fabularia*, morphologically speaking, is a Biloculine *Miliola* with labyrinthic chambers.

The Hauerininæ constitute a group of dimorphous forms connecting the Miliolininæ with the Peneroplidinæ. The sub-family is best represented by the genus *Hauerina*, which, except in its very early growth, may be described as a *Cornuspira* or *Spiroloculina* with more than two segments in each convolution; and the closely allied *Planispirina* is essentially a *Hauerina* with the chamber-walls spreading over the lateral faces of the test in Nummuline fashion.

The genus *Peneroplis*, like *Cornuspira*, is spiral from the commencement, and each convolution is divided into many segments. The spire is either nautiloid or explanate, and the later chambers often diverge in a straight, linear series. *Orbiculina* resembles the spiral *Peneroplides*, but has its chambers subdivided into chamberlets, and in this particular forms the connecting link with *Orbitolites*. The simpler varieties of *Orbitolites* begin spirally, the more complex usually commence with a large primordial chamber; but both almost immediately assume a cyclical plan of growth, and the mature shell consists of a large number of annular chambers, each divided into numerous chamberlets. *Alveolina* has a spiral test, more or less elongated on the axis of convolution, and the chambers subdivided into chamberlets. From a morphological point of view it is an

[1] *Phil. Trans.*, 1856, p. 551; *ibid.*, 1858, p. 4.

Orbiculina drawn out at the umbilici, so as to form a subglobular, oval, or fusiform shell.

Lastly, *Keramosphæra* is a little globe made up of concentric layers, each layer composed of a large number of chamberlets,—in other words, a spherical Orbitolite.

From end to end, from *Cornuspira* and *Spiroloculina* to *Orbitolites* and *Alveolina*, if not to *Keramosphæra*, the series is nearly unbroken. Each successive type embodies only a slight modification of its predecessor, either in the number of the chambers, their more or less symmetrical disposition, whether spiral or cyclical, or their subdivision into chamberlets; but even the features selected to characterise the genera are open to constant variation, and the genera themselves are for the most part additionally connected by dimorphous forms.

Sub-family 1. **Nubecularinæ.**

Nubecularia, Defrance.

Nubecularia, Defrance [1825], Blainville, Jones and Parker, Carpenter, Karrer and Sinzow, Brady, Terquem, Siddall, Seguenza.
Amorphina, Parker [1860].
Sagrina, pars, Brady [1879].

An excellent account of the genus *Nubecularia* is given by Dr. Carpenter in the Introduction to the Study of the Foraminifera, and its wide range of variation in external form is well illustrated in the accompanying drawings made from recent specimens by Mr. George West.

More recently Karrer and Sinzow[1] have described and figured a series of large thick-shelled varieties which occur in extraordinary abundance in certain Tertiary deposits in the south of Russia, notably in the Sarmatian Sands of Kischenew in Bessarabia; and these have been recognised by Prof. Parker as identical in general characters with specimens in the collection of the late Sir Charles Lyell from Miocene localities in the south of France.

The two memoirs referred to, with the addition of a brief notice by Jones and Parker,[2] of a fossil species of much earlier geological age almost complete the published literature of the genus. The Challenger gatherings furnish two interesting modifications of the type, not previously recorded, but otherwise throw but little new light upon the group.

Nubecularia is found living in the laminarian and littoral zones and, rarely, at greater depths, in the seas of tropical and to some extent of temperate latitudes. Its geological history dates back to the Triassic period, and it is found also in the Oolite; but in the fossil condition it is best known as a constituent of some Tertiary deposits of France, Italy, Russia, and elsewhere.

[1] *Sitzungsb. d. k. Akad. Wiss. Wien*, vol. lxxiv. p. 272, pl. i.
[2] *Quart. Journ. Geol. Soc.*, vol. xvi. p. 455, pl. xx.

Nubecularia lucifuga, Defrance (Pl. I. figs. 9–16).

"Vermiculi *crustati*," Soldani, 1789, Testaceographia, vol. i. part 1, p. 34, pl. xxxi. fig. *gg* to pl. xxxii. fig. *ss*.

Nubecularia lucifuga, Defrance, 1825, Dict. Sci. Nat., vol. xxv. p. 210; Atlas Zooph., pl. xliv. fig 3.

" " Blainville, 1834, Man. d'Actinol., pl. lxvi. fig. 3, *a–d*.

" " Parker and Jones, 1863, Ann. and Mag. Nat. Hist., ser. 3, vol. xii. p. 209, No. 64.

" *cristellarioides*, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i., Mém. III., p. 14, pl. i. fig. 5.

This is one of the simplest of all the testaceous Rhizopods, and, perhaps for that reason, one of the most variable in contour and habit of growth. The shell of recent specimens is thin, as compared with the stout calcareous walls of some of the fossil varieties, and imperforate; it is either free or adherent—that is to say, under favourable circumstances it prefers the support of some foreign body over which it can spread indefinitely, but if detached leads equally well an independent existence;—it is polythalamous, and the normal plan of growth is spiral, but very early in the life of the animal all regular arrangement is usually lost, and the chambers follow each other in more or less annular, rectilinear, or acervuline fashion. The septation is often partial or incomplete, and in adherent specimens the shelly investment is tent-like, and covers only the superior surface of the animal. The general aperture is either terminal and simple, or takes the form of a number of rounded or irregular orifices variously disposed. The shell is commonly white, and its texture porcellanous; but it shares the tendency of many other *Miliolidæ* to agglutinate sand-grains and to become rough externally, as shown in fig. 12. The specimens represented by figs. 9, 10 are parasitic upon fibres, apparently of vegetable origin, and are not to be confounded with forms like *Nubecularia divaricata*, in which the segments are united by calcareous stoloniferous tubes.

The typical *Nubecularia lucifuga* is very rare in the Challenger collections, indeed, it has only been met with at one Station, namely, off Tongatabu, Friendly Islands, depth, 18 fathoms. Its scarcity is probably due to the fact that very few gatherings were made from shore-pools or littoral sands. It is nevertheless a common species in the still, shallow-water margins of warm or temperate latitudes. The figured specimens are from the coast of Tripoli and from the beach near Melbourne, Australia. The species is abundant on the shores of the Mediterranean, in the East and West Indies, and elsewhere. One or two starved specimens, dredged off the coast of Devonshire, are evidence of its occasional presence in the British seas, and probably indicate its northern geographical limit.

In the confusion that appears to exist between the adherent *Nubeculariæ* and their arenaceous isomorphs of the sub-genus *Webbina*, it is not easy to speak with accuracy concerning the geological distribution of *Nubecularia lucifuga;* but that it occurs

plentifully in the Tertiaries of France and of some parts of eastern Europe is recorded on good authority.

Nubecularia inflata, n. sp. (Pl. I. figs. 5–8).

Test consisting of a few, misshapen, inflated segments, irregularly combined; aperture either single and simple, or, more usually, consisting of a number of rounded orifices variously placed. Diameter, $\frac{1}{30}$th inch (0·84 mm.), more or less.

This is a protean species that only admits of description in very general terms. It supplies the links which connect the typical *Nubecularia lucifuga* with aberrant Milioline forms like *Miliolina labiosa*, d'Orb., differing from the former in its comparatively modest size, the relatively small number of its segments, and their inflated contour, and from the latter in its extreme irregularity of growth, and the tendency exhibited by the individual chambers to form independent apertures. Amongst the littoral sands of our own coast wild-growing specimens of *Miliolina subrotunda* with some of the characters of *Nubeculariæ* are not uncommon, but in the absence of other distinctive marks their Milioline affinity is usually indicated by the aperture.

I have notes of the occurrence of *Nubecularia inflata* in sand and mud from the following localities:—off Honolulu coral-reefs, Sandwich Islands, 40 fathoms; off Tongatabu, 18 fathoms; off Tahiti, Society Islands, 420 fathoms; Nares Harbour, Admiralty Islands, 17 fathoms; and Balfour Bay, Kerguelen Island, 20 to 50 fathoms; and at some of these points it is tolerably plentiful.

Nubecularia tibia, Jones and Parker (Pl. I. figs. 1–4).

Nubecularia tibia, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 455, pl. xx. figs. 48–51.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 52, pl. viii. figs. 1, 2.
„ „ Walford, 1879, Proc. Warwick. Nat. & Arch. Field Club for 1878, Suppl., p. 22.

Nubecularia tibia is a porcellanous isomorph of *Nodosaria*. The test consists of a few ovate, pyriform, sub-cylindrical, or occasionally misshapen segments united end to end, and when regular bears considerable resemblance to some of the slender *Dentalinæ*. The aperture is a simple, round, terminal orifice, sometimes bordered by a thickened or everted lip. The shell is opalescent or opaque-white and imperforate. Owing, perhaps, to the thinness of the walls and the slenderness of the stoloniferous tubes, specimens are scarcely ever found with more than three segments, the maximum length being about $\frac{1}{30}$th inch (0·84 mm.).

A careful comparison of specimens from all the known sources, recent and fossil

reveals no characters not common to the entire series, none at any rate that can be regarded as zoologically distinctive.

Nubecularia tibia occurs at five of the Challenger Stations, always in comparatively shallow water, namely:—off Culebra Island, West Indies, 390 fathoms; off Raine Island, Torres Strait, 155 fathoms; Humboldt Bay, Papua, 37 fathoms; Philippine Islands, 95 fathoms; and the Inland Sea, Japan, 15 fathoms; but it is by no means a common form at any of these localities.

The interest attaching to this simple little organism depends upon the fact that until lately it had only been recognised as a Triassic or Rhætic fossil. It was first described by Jones and Parker, *loc. cit.*, in their paper upon the Foraminifera of certain marls occurring at Chellaston in Derbyshire. More recently I have identified specimens in Mr. E. A. Walford's collection of microzoa from the Upper Lias of Banbury, and this completes the record of its geological history; it is nevertheless quite possible that, owing to its minute size and inconspicuous appearance, it may have been overlooked in other localities.

Nubecularia divaricata, H. B. Brady (Pl. LXXVI. figs. 11–15).

Sagrina divaricata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 276, pl. viii. figs. 22–24.

Test free, moniliform; consisting (typically) of three or four more or less distinct segments, united by stoloniferous tubes. Segments subglobular, rough and arenaceous externally; stoloniferous tubes narrow, cylindrical, with thin calcareous walls, and smooth externally. Aperture an elongated tubular neck, often longitudinally furrowed, terminating in a phialine lip. Length, $\frac{1}{50}$th inch (0·5 mm.).

The further study of this interesting little organism has led to considerable modification of the terms employed in the original description; for, misled on the one hand by the delicately thin and almost transparent stoloniferous tubes, and on the other by the subarenaceous tests of some of the forms included by d'Orbigny in the genus *Sagrina*, the species was placed, to begin with, in a wrong position. It is, in fact, only by the careful examination of the shell, in section and otherwise, by transmitted light, that the porcellanous texture of the walls can be satisfactorily made out; but viewed in this way the test exhibits all the structural features of the arenaceous *Miliolæ*.

The stoloniferous tubes vary a good deal in length, or at any rate in the extent to which they are visible. In some cases the length is as much as half the diameter of the segments, whilst in others the neighbouring segments appear closely approximated, and the stolons are scarcely seen, owing to the increased thickness of the sandy incrustation. The phialine neck often resembles that of *Nubecularia tibia*, but it occasionally takes exaggerated forms such as those represented in figs. 15, 16.

Nubecularia divaricata has only been observed in three localities :—Humboldt Bay, on the north coast of Papua, 37 fathoms ; off Raine Island, Torres Strait, 155 fathoms ; and off Tongatabu, Friendly Islands, 18 fathoms.

Sub-family 2. Miliolininæ.

(*Miliola* and *Miliolites*, Lamarck.)

Messrs. Parker and Jones, recognising the close relationship which exists amongst the subordinate groups of the more strictly Milioline Foraminifera, and the impossibility of dividing the series except by lines more or less lax and conventional, treat the whole as constituting a single genus, *Miliola*, and employ the d'Orbignian terms *Biloculina*, *Spiroloculina*, *Triloculina*, and *Quinqueloculina* in subgeneric sense. This method of dealing with the subject presents certain advantages, and so long as it does not entail a system of trinomial nomenclature it may be adopted without inconvenience. I venture only to differ from the authors in one minor point, namely, the questionable desirability of attempting to separate the Triloculine from the Quinqueloculine forms.

The morphological relationship between the first two of these subgeneric groups, *Biloculina* and *Spiroloculina*, involves but little difficulty, and is readily understood. Typically the plan of growth is the same,—two chambers on the same plane to each convolution ; but whilst *Biloculina* has wide, somewhat inflated segments, each of which in its turn encloses all those previously formed on the same side, so that only two segments are visible externally, *Spiroloculina* has narrow, non-embracing chambers, arranged alternately and symmetrically, so that every segment is seen on both sides of the shell. These are distinctions so generally accepted, and under ordinary circumstances so easily recognised, that the occurrence of an occasional specimen with intermediate characters is of no practical inconvenience.

But with the Triloculine and Quinqueloculine members of the series the case is otherwise. The subdivision of the *Miliolæ* proposed by d'Orbigny in his Tableau méthodique de la classe des Céphalopodes,[1] has been employed by systematists, with but few exceptions, to the present time. It contains the two following generic descriptions under the family Agathistègues :—

" Genre III. *Triloculina*.—Loges opposées sur trois côtés ; la même forme à tous les âges ; trois loges apparentes."

" Genre V. *Quinqueloculina*.—Loges opposées sur cinq côtes ; cinq loges apparantes."

The whole weight of the distinction embodied in these definitions hangs on the words " à tous les âges," which, it is scarcely necessary to point out, admits a most undesirable basis for the division of an unusually variable group. The number of varietal forms that can be said to have uniformly only three external segments is exceedingly limited, whilst,

[1] *Annales des Sci. Nat.*, 1826, vol. vii. pp. 299, 301.

on the other hand, most of the *Quinqueloculinæ* have a Triloculine stage of growth. Under d'Orbigny's definitions young specimens and adults of the same variety have over and over again been placed as distinct species in separate genera. Amongst smooth-shelled forms the anomaly might pass unnoticed, but amongst those in which peculiarity of surface-ornamentation affords the principal distinctive character the double nomenclature becomes palpably absurd. There is still another objection to these generic terms, which is brought into stronger light than heretofore by specimens obtained from the Challenger dredgings, namely, that the number of exposed segments is not necessarily either three or five. In one striking subarenaceous species, *Miliolina alveoliniformis*, there are often seven or eight, long, narrow chambers in the peripheral whorl; and in another arenaceous form, *Miliolina triquetra*, instead of two segments, one up and one down, forming the axial circuit of the test throughout, there are usually three segments in the final circuit of adult shells, the contour becoming flattened as in *Spiroloculina*, and more or less triangular. Neither of these could be included in any of the Milioline genera as hitherto constituted. Instances of the same sort might readily be multiplied, but enough has been said to show that *Triloculina* and *Quinqueloculina* may properly be discarded as generic or even subgeneric names, just as *Adelosina* was long since abolished and for similar reasons, and that some general name less open to objection should be found for this portion of the group. Prof. Williamson, after discussing the question with his usual acumen,[1] adopts the term *Miliolina* for the section under consideration, and with a slight modification of the characters assigned to it in his Monograph, its general adoption would be a distinct gain to systematic zoology.

The position taken by Parker and Jones is unassailable, viewed from a strictly biological standpoint. The great diversity amongst Foraminifera in the comparative constancy and distinctiveness of the minor peculiarities which characterise the subordinate forms has already been adverted to. Many instances might be cited in which apparently trivial characters are as reliable and as little subject to variation as those of animals more highly organised, but such is not the case amongst the *Miliolæ*. The successive modifications merge one into the other so as to constitute an almost unbroken series, and the task of the zoologist resolves itself into the selection of the salient forms most suitable for quasi-specific names. Under these circumstances, the term *Miliola* may very properly be used in a generic sense to comprehend a great variety of closely associated forms having the same general type of structure; whilst *Biloculina*, *Spiroloculina*, and *Miliolina* represent subordinate divisions, under which, for more easy identification and for convenience of nomenclature, it is necessary to arrange them.

[1] Recent Foraminifera of Great Britain, p. 83.

Biloculina, d'Orbigny.

Miliolites, pars, Lamarck [1804].
Lagenula, pars, Fleming [1822].
Miliola, pars, Defrance [1824], Blainville.
Pyrgo, Defrance [1824], Blainville.
Biloculina, d'Orbigny [1826], Reuss, Bornemann, Costa, Parker and Jones, Williamson, Terquem, Karrer, Carpenter, Seguenza, Brady, Schwager, Schulze, &c.
Renoidea, Brown [1827].
Nummulina, Macgillivray [1843], Thorpe.

The genus *Biloculina* requires no minute description. It may be said to comprise just those Milioline Foraminifera which have only two chambers visible externally, each successive segment entirely embracing the previous ones on the same side; and although the Biloculine form of shell merges by insensible degrees through such varieties as *Biloculina tubulosa*, Costa, *Biloculina lucernula*, Schwager, *Triloculina cuneata*, Karrer (the Biloculine form of which is shown in Pl. I. figs. 19, 20), and others, into the Triloculine condition, the typical arrangement of the segments is less liable to variation than that of the allied groups of *Miliolæ*.

The geographical distribution of the genus is world-wide, and its bathymetrical range includes every depth from the rock-pools of the littoral zone down to 3000 fathoms.

Perhaps the most noteworthy fact in connection with the occurrence of the Biloculine type is that brought into notice by Prof. G. O. Sars, of Christiania, in his official report on the Norwegian sea-fisheries for the year 1876,[1] in which he gives a short account of the biological conditions of the "deep-water cold area" of the northern part of the North Atlantic. The area so designated occupies a considerable portion of the region between Norway, Bear Island, and Spitzbergen on one side, and the Faröe Islands, Iceland, and Greenland on the other. It has a tolerably uniform bottom temperature of from 0° to 1°·6 C. (32° to 34°·9 Fahr.), and the depth ranges from 300 to 2000 fathoms. The sea-bed, especially of the deeper portions of the area, consists of a soft, light-coloured, sticky mud, of which the most important organic constituent is the porcellanous foraminifer, *Biloculina ringens*. This deposit has been named "Biloculina clay," but the term is not to be understood in quite the same sense as that in which the words "Globigerina ooze" or "Radiolarian ooze" are employed; for although of the microzoa present, by far the most conspicuous are *Biloculinæ*, the entire number of specimens of that genus is stated not to amount to more than two per cubic centimetre.[2] Nevertheless, the deposit has certain well-marked peculiarities, and the following results of the

[1] Indberetninger til Departementet for det Indre fra Professor Dr. G. O. Sars om de af ham i Aarene, 1864–1878, anstillede Undersøgelser angaaende Saltwandsfiskerierne. Christiania, 1879.

[2] *Vide* Schmelk, on Oceanic Deposits, *Norwegian North Atlantic Expedition*, 1876–1878, pt. ix., *Chemistry*, p. 49 *et seq.*

examination of a sample, kindly furnished by Prof. Sars, are not without interest as bearing upon the relative proportion of its foraminiferal constituents.

The locality from which the material was obtained is given as follows:—"Lat. 65° 47′·5 N., long. 3° 7′ W.; depth, 1862 fathoms; temperature at the bottom, 1°·2 C." [about 34° Fahr.].

As the fine impalpable silt had been already partly removed, the cleaning was completed by washing on a sieve in the usual way. The loss was about 6 per cent. of the entire weight, and of the impalpable matter thus separated about one half was calcareous, the remainder fine siliceous sand. I have no information as to the proportion of impalpable mud before the preliminary washing, but as it is said to be sufficient to incorporate the whole into a sticky paste which on being dried forms a hard, light-coloured, calcareous mass, it must be considerable. The composition of the material in the condition in which it was received was as follows—the proportions stated being by weight:—

Biloculina ringens (one half being entire shells), . . .	50 per. cent.
Haplophragmium latidorsatum,[1]	20 „
Globigerina borealis, ...	4 „
Sand and small fragments of rock with a few Foraminifera other than the above-named, ...	20 „
Impalpable débris, ...	6 „
	100

The specimens of *Biloculina* are nearly all of the stout, inflated, typical form, with a small admixture of the depressed carinate variety, *Biloculina depressa*, d'Orb. Beyond the species above named, the sample contained no microzoa worthy of note.

Biloculina irregularis, d'Orbigny (Pl. I. figs. 17, 18).

Biloculina irregularis, d'Orbigny, 1839, Foram. Amér. Mérid., p. 67, pl. viii. figs. 22–24.
(?) *Biloculina globulus*, Reuss, 1863, Sitzungsb. d. k. Akad. Wiss. Wien, vol. xlviii. p. 40, pl. i. fig. 4, *a–c*.
Biloculina ventricosa, Id., 1867, *Ibid.*, vol. lv. p. 69, pl. i. fig. 9, *a–c*.

Dr. Steinmann has shown that the *Biloculina contraria* of d'Orbigny is not truly Biloculine in the adult condition, but that it exhibits a type of structure which may properly be regarded as generically distinct. There are nevertheless veritable *Biloculinæ* which take the so-called "contrary" mode of growth, best understood by supposing a specimen of *Biloculina sphæra* compressed to a greater or less degree at the two sides instead of in the normal way from front to back. Such are the *Biloculina irregularis* of d'Orbigny and the *Biloculina ventricosa* of Reuss.

The amount of compression varies a good deal in different specimens. Those which are relatively thickest and least flattened make some approach to the contour of *Bilocu-*

[1] This is the *Lituola subglobosa* of M. Sars.

lina sphæra, but they may generally be distinguished by the ordinary Milioline aperture, and by the extent to which the penultimate chamber is exposed. Probably the form named by Reuss *Biloculina globulus* (*loc. cit.*) is one of these; it differs considerably from that species as originally figured by Bornemann.

Specimens of *Biloculina irregularis* have been obtained from Challenger material dredged off Palma, Canaries, 1125 fathoms; off Sombrero Island, 450 fathoms; south of Pernambuco, 350 fathoms; in mid-ocean, South Atlantic, 1415 fathoms; off Fiji, 610 fathoms; off Tahiti, 620 fathoms; and north of Papua, 1070 fathoms.

The localities of the fossil (Tertiary) forms figured by Reuss, above referred to, are respectively the Septaria-clay of Hermsdorf, near Berlin, and the Salt-beds of Wieliczka in Galicia.

Biloculina sphæra, d'Orbigny (Pl. II. fig. 4, *a.b.*).

Biloculina sphæra, d'Orbigny, 1839, Foram. Amér. Mérid., p. 66, pl. viii. figs. 13–16.
„ *globulus*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesell., vol. vii. p. 349, pl. xix. fig. 3, *a*, *b*.
„ *sphæra*, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 466, pl. xlviii. fig. 1, *a*, *b*.
„ *globulus*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 464;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxxv. figs. 30–32.

There are few Foraminifera more easily identified than well-grown specimens of *Biloculina sphæra*. The globular contour first attracts attention, then the investing character of the final chamber, which encloses the whole of that preceding it except a little circular patch just below the aperture, and lastly the aperture itself, which often presents somewhat anomalous features.

D'Orbigny in the "South America" monograph, *loc. cit.*, suggests rather than delineates the orifice, and the figure referred to in my own paper on Shetland Foraminifera was taken from a specimen of the particular form which is common in the comparatively shallow water of the Scottish coast, and shows no characteristic deviation from the ordinary Biloculine type. The shell figured in Pl. II. fig. 4 is a fair representative of the deep-water examples of the species; but the bordered V-shaped slit, which is perhaps its most conspicuous feature, is only one out of many forms the aperture assumes, and it is quite as common to find in deep-sea specimens a labyrinthic or dendritic orifice such as that portrayed in the annexed woodcut (fig. 1).

Fig. 1.—Labyrinthic aperture of *Biloculina sphæra*. Magnified 40 diam.

That the shell figured by Bornemann, *loc. cit.*, under the name *Boliculina globulus*, as well as those above referred to in the plates of von Schlicht's memoir, belong to the present species, hardly admits of doubt. Bornemann's name, however, is used by Reuss, in his notice of the Foraminifera of the Septaria-clay of

Offenbach, for a somewhat different variety, apparently related to the less compressed forms of *Biloculina irregularis*.

Biloculina sphæra is found in all the great ocean basins, though it can scarcely be regarded as a common species. In the North and South Atlantic and South Pacific it is by no means unfrequent, but it is more sparingly distributed in the North Pacific and Indian Oceans. Its bathymetrical range extends from shallow water down to 2300 fathoms, but it is rare at greater depths than 1000 fathoms.

It occurs as a Tertiary fossil in the Septaria-clays of several districts in North Germany.

Biloculina bulloides, d'Orbigny (Pl. II. figs. 5, 6).

"Conchula minima," &c., Plancus, 1739, De Conch. min. not., p. 23, pl. ii. fig. 6.
Biloculina bulloides, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 297, No. 1, pl. xvi. figs. 1–4. Modèle, No. 90.
,, *peruviana*, Id., 1839, Foram. Amér. Mérid., p. 68, pl. ix. figs. 1–3.
,, *ringens*, Parker, Jones and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 35.
,, *lucernula*, Schwager, 1866, Novara-Exped., Geol. Theil., vol. ii. p. 202, pl. iv. fig. 17, *a*, *b*.

D'Orbigny's figure of *Biloculina bulloides* in the Annales des Sciences serves as a useful type for a group of thick-shelled, subglobular *Biloculinæ* affecting moderately deep water. The specimens are characterised by having inflated segments, a small circular aperture, generally though not invariably placed on the slightly produced or tubular end of the final segment, and a somewhat coarse shell with roughish exterior.

The species is common in the North Atlantic, but comparatively rare in other seas. It is at its best at depths of from 300 to 1000 fathoms, though small examples are occasionally found as low down as 2750 fathoms. It occurs at one of the Challenger Stations in the South Atlantic, and at one in the South Pacific, in either case at a depth of more than 2000 fathoms; off the Cape of Good Hope, 150 fathoms; and in two localities amongst the islands south of New Guinea, in comparatively shallow water.

Biloculina ringens, Lamarck, sp. (Pl. II. figs. 7, 8).

"Frumentaria *Ovula*," Soldani, 1795, Testaceographia, vol. i., part 3, p. 228, pl. cliii. fig. S.
Miliolites ringens, Lamarck, 1804, Ann. du Muséum, vol. v. p. 351; vol. ix., pl. xvii. fig. 1.
Biloculina ringens, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 297, No. 2.
,, *canariensis*, Id., 1839, Foram. Canaries, p. 139, pl. iii. figs. 10–12.
,, *clypeata*, Id., 1846, For. Foss. Vien., p. 263, pl. xv. figs. 19–21.
,, *simplex*, Id., Ibid., p. 264, pl. xv. figs. 25–27.
,, *turgida*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesell., vol. iii. p. 85, pl. vii. fig. 55.
,, *ringens*, Williamson, 1858, Rec. For. Gt. Br., p. 79, pl. vi. figs. 169, 170.
,, ,, Jones, Parker and Brady, 1866, Foram. Crag, p. 5, pl. iii. figs. 26–28.

The extreme variability of *Biloculina ringens* in respect of the size and form of the

aperture, and the shape of the valvular tooth, as well as in the degree of angularity of the outer margin of the shell, has been dwelt upon by many writers; and the case has been so fully stated by Williamson (Rec. For. Gt. Br., p. 80) that there is little left to be said on the subject. It is sufficient to repeat that in the genus *Biloculina* neither the shape of the aperture nor the roundness or irregularity of the margin furnishes any character sufficiently distinctive to be of more than comparative value to the systematist. It is convenient to recognise certain forms that may be roughly distinguished from each other by their general contour, such as *Biloculina bulloides*, the typical *Biloculina ringens*, and *Biloculina depressa*, together with a few others that appear to be somewhat more definite local varieties; but the fact remains, that from end to end of the generic series the variation is one of degree only. With slight exception in the matter of surface ornamentation, no new character makes its appearance, and the successive links in the chain only differ amongst themselves in the greater or less development of a few features common to the whole.

Biloculina ringens abounds in almost every sea, and at almost every depth hitherto explored, from shore-pools between tide-marks to nearly 3000 fathoms.

As a fossil it is found with other *Miliolæ* in Tertiary deposits as far back as the Eocene of the Paris Basin.

Biloculina ringens, var. *denticulata*, nov. (Pl. III. figs. 4, 5).

General contour proportionately longer and margin somewhat more angular than in the typical *Biloculina ringens*. The inferior portion of the peripheral margin of the last chamber more or less toothed. Length, $\frac{1}{33}$rd inch (0·75 mm.).

The dentate condition of the inferior portion of the margin of the test varies much in degree; otherwise the specimens are very uniform, not only in general contour, but in the shape of the aperture, in size, and in other minor characters. The distribution is limited to certain comparatively narrow areas, and the distinctive features appear to be those of a tolerably well-marked local variety rather than of a species, even in the lax interpretation of the term permissible in speaking of Foraminifera.

Biloculina denticulata belongs to the coral-reef fauna. The best specimens have been obtained from the Honolulu Reefs, 40 fathoms; off Tongatabu, Friendly Islands, 18 fathoms; and off the Admiralty Islands, 15 to 20 fathoms. A very similar variety, but without the indentations of the margin, occurs off St. Vincent, Cape de Verde Islands, 11 fathoms; and off Kandavu, Fiji, 610 fathoms.

Biloculina ringens, var. *striolata*, nov. (Pl. III. figs. 7, 8).

General characters the same as those of var. *denticulata*, but having in addition a surface ornamentation of slightly irregular, raised, longitudinal striæ over the inferior portion of the shell, especially of the penultimate chamber. Length, $\frac{1}{33}$rd inch (0·75 mm.).

The remarks appended to the description of the last variety apply with equal or greater force to the present, the distribution of which is even more narrowly circumscribed.

Biloculina striolata has only been noticed in three or four localities, all of them amongst the islands on the southern shores of Papua just west of Torres Straits; namely, off Booby Island, 6 fathoms and 8 fathoms; off Wednesday Island, 8 fathoms; and Flinders Passage, 7 fathoms.

Biloculina comata, H. B. Brady (Pl. III. fig. 9, *a.b.*).

Biloculina comata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N.S., p. 45.

General characters similar to those of *Biloculina ringens* or *Biloculina bulloides*, but having a surface ornamentation of close, regular, longitudinal striæ. The length of the figured specimen is about $\frac{1}{30}$th inch (0·85 mm.), but the species often attains much larger dimensions.

Biloculina comata occurs, in company with other large *Miliolæ*, at depths of from 300 to 600 fathoms in the North Atlantic and elsewhere. It has been met with at five Challenger Stations, in localities very far apart, namely:—off Culebra Island, West Indies, 390 fathoms; north of Madeira, 620 fathoms; on the coast of South America, off Pernambuco, 350 fathoms; off Sydney, 420 fathoms; and North of New Guinea, 1070 fathoms. It appears also in one or two of the "Porcupine" dredgings in the North Atlantic at similar depths.

Biloculina elongata, d'Orbigny (Pl. II. fig. 9, *a.b.*).

"Frumentaria *Ovula*," Soldani, 1795, Testaceographia, vol. i., part 3, p. 228, pl. cliii. fig. *M. Q.*
"Frumentaria *milium*," Id. Ibid., p. 231, pl. clvi. fig. *vv.*
Biloculina elongata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 298, No. 4.
„ *bougainvillei*, Id. 1839, Foram. Amér. Mérid., p. 67, pl. viii. figs. 22–24.
„ *patagonica*, Id. Ibid., p. 65, pl. iii. figs. 15–17.
„ *ringens*, var. *patagonica*, Williamson, 1858, Rec. For. Gt. Br., p. 80, pl. vii. fig. 175, 176.
Miliola (*Biloculina*) *elongata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 409, pl. xvii. fig. 88, 90, 91.
Biloculina elongata, Parker, Jones and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 247, pl. viii. fig. 6.

In selecting a name out of the many that have been devised for the small, attenuated or oval variety of *Biloculina*, it is impossible to pass over that given by d'Orbigny to the specimens figured by Soldani in the Testaceographia. Unfortunately the author did not choose the most characteristic of Soldani's drawings of the species, but founded his *Biloculina elongata* on figures which can only be recognised with difficulty, and probably for this reason the name has been ignored by most subsequent writers. An excellent figure, in front view, is given by Soldani in pl. clvi. fig. *v.v.* That the *Bilocu-*

lina elongata of the Tableau Méthodique is the same in all essential features as the *Biloculina bougainvillei* and *Biloculina patagonica* of the "South America" memoir, scarcely admits of a doubt. The segments vary a good deal in form in different specimens, and it is seldom they are quite so regular and symmetrical as in that figured in Pl. II. fig. 9.

Biloculina elongata is cosmopolitan. It is common in the littoral and shallow-water sands of our own shores and throughout the temperate zones, but seeks somewhat deeper water in the tropics. Judging from the Challenger gatherings, it appears to be more abundant in the North Atlantic and South Pacific than elsewhere.

Biloculina depressa, d'Orbigny (Pl. II. figs. 12, 15–17; Pl. III. figs. 1, 2).

"Frumentaria *Lenticulæ*," Soldani, 1795, Testaceographia, vol. i., part 3, p. 231, pl. clv. figs. *yy*, *zz*.

Biloculina depressa, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 298, No. 7;—Modèle, No. 91.

„ *carinata*, Id., 1839, Foram. Cuba, p. 148, pl. viii. fig. 24; pl. ix. figs. 1, 2.

„ *lunula*, Id., 1846, For. Foss. Vien., p. 264, pl. xv. figs. 22–24.

„ *amphiconica*, Reuss, 1850, Denkschr. d. k. Ak. Wiss. Wien, vol. i. p. 382, pl. xlix. fig. 5.

„ *ringens*, var. *carinata*, Williamson, 1858, Rec. For. Gt. Br., p. 79, pl. vii. figs. 172–174.

Miliola (*Biloculina*) *depressa*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 409, pl. xvii. fig. 89, *a*, *b*.

Biloculina depressa, Jones, Parker and Brady, 1866, Foram. Crag., p. 6, pl. iii. figs. 29, 30.

As may be inferred from what has been already stated, the only distinctive features of *Biloculina depressa* are the compressed contour, and the thin, angular, peripheral margin. The degree of compression varies greatly, and the thicker specimens furnish the connecting links between the present species and the typical *Biloculina ringens*. In like manner the aperture presents every gradation of form from the nearly round, somewhat tubular mouth, represented in Pl. II. fig. 15, to the broader orifice of figs. 12 and 16, and even to the linear slit shown in Pl. III. figs. 1, 2. In rare instances when the aperture takes the long, slit-like character, the superior lip projects somewhat beyond the normal periphery of the shell; and on the production of a fresh segment this projection is not enclosed with the rest of the margin, but remains as a sort of appendage to the inferior extremity, and gives rise to such modifications as figs. 1, 2 just referred to, or as the specimen figured by Karrer (Geol. d. K. F.-J. Wasserleitung, pl. xvi. *a*, fig. 7). This peculiarity is not confined to the compressed varieties, but is also met with in the stouter species.

The distribution of *Biloculina depressa* is coextensive with that of the type, both from a geographical and geological point of view. It must, however, be mentioned that Terquem and Berthelin figure under the name *Biloculina liassina* (Mém. Soc. géol. France, sér. 2, vol. x. p. 77, pl. xvi. fig. 7) specimens obtained from the Middle Lias of Essey-lès-Nancy, which appear to me indistinguishable from the present species except

in the absence of any appendicular tongue to the aperture—a character which may be accidental, and in any case one to which very little importance can be attached.

Biloculina depressa, var. *serrata*, nov. (Pl. III. fig. 3, *a.b.c.*).

"Frumentaria *Lenticulæ*," Soldani, 1798, Testaceographia, vol. ii. p. 54, pl. xix. fig. *o*.

A variety presenting the same general characters as *Biloculina depressa*, but having a dentate peripheral edge, the teeth being angular and the points directed outwards.

In deep water the margins of the large *Biloculinæ* frequently assume a dentate form, though the peculiarity is one that varies very much in degree. Well-marked specimens have been noted at seven Stations (Challenger and "Porcupine") in the North Atlantic, and at four Stations in the South Pacific, the depth ranging from 580 to 1750 fathoms.

Biloculina depressa, var. *murrhyna*, Schwager (Pl. II. figs. 10, 11).

Biloculina murrhyna, Schwager, 1866, Novara-Exped., Geol. Theil, vol. ii. p. 203, pl. vi. fig. 15, *a–c*.

This is a mere varietal modification of *Biloculina depressa*, distinguished by having two angular or pointed projections on the peripheral edge near the base of the shell, placed symmetrically a little distance apart.

Memoranda have been kept of the occurrence of similar bicaudate specimens at four Stations; one in the North and one in the South Atlantic, one in the North and one in the South Pacific, at depths ranging from 1180 to 1900 fathoms.

The fossil specimen figured by Dr. Schwager is from a late Pliocene deposit in the Nicobar Islands.

Biloculina lævis, Defrance, sp. (Pl. II. figs. 13, 14).

Pyrgo lævis, Defrance, 1824, Dict. Sci. Nat., vol. xxxii. p. 273; atlas, pl. lxxxviii. fig. 2.
,, ,, Blainville, 1825, Malacologie, p. 482, pl. lxii., bis. fig. 2.
Biloculina lævis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 298, No. 8.

The little shell, figured by Defrance and Blainville under the name *Pyrgo lævis*, differs from most of its congeners in being to some extent bicarinate. The line of union between each fresh chamber and the preceding one is a little within the periphery of the latter; so that while the margin of the last segment forms the periphery of the test, the free edge of the penultimate makes a parallel border, though it does not project so far. A character of this sort naturally varies a good deal in different specimens. It is well shown in fig. 14, which closely resembles Blainville's drawing; not so well in fig. 13, of which the general contour of the shell in other respects approaches that of *Biloculina depressa*.

Biloculina lævis occurs at two Stations in the North Atlantic, at depths of 1215 and 390 fathoms respectively, and in shallow water, Humboldt Bay, Papua.

The specimens originally described by Defrance were from the Paris Tertiaries.

Biloculina tubulosa, Costa (Pl. III. fig. 6 *a.b.c.*).

Biloculina tubulosa, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 309, pl. xxiv. fig. 7.

Under the above name Costa has described a variety of *Biloculina* allied to *Biloculina bulloides*, but differing from that species in having a wide fissure or depression on both faces of the test on the line of union between the two outermost segments. It is obvious that a shell so constructed can only remain Biloculine so long as the depression is regular, and equal at the two sides, and that any obliquity is liable to expose a portion of the ante-penultimate segment, or in other words, to render it Triloculine. In point of fact, the specimen figured by Prof. Costa is in the latter condition.

In one of the Challenger dredgings a form with similar peculiarities, which may confidently be assigned to the same species, is tolerably abundant. The specimens are of considerable size, often $\frac{1}{20}$th inch (1·25 mm.) in length. In their young state they are generally Biloculine, and sometimes retain the same condition when fully grown; but more commonly in the adult shell a small portion of the surface of a third chamber is exposed, as shown in the drawing, fig. 6, *c*.

An analogous passage form is figured by Dr. Karrer, from the Miocene of Kostej (Sitz. d. k. Akad. Wiss. Wien, vol. lvii. pl. i. fig. 11), under the name *Triloculina intermedia*; that, however, appears to be more distinctly Triloculine than the recent specimens, and the margins of the two outer segments are subcarinate.

Biloculina tubulosa is common in one of the dredgings off Kandavu, Fiji Islands; depth, 210 fathoms.

As a fossil it is rare in the Pliocene deposits of Lequile and Ischia, Italy (Costa).

Spiroloculina, d'Orbigny.

Miliolites, pars, Lamarck [1804].
Miliola, pars, Defrance [1824], Bronn.
Spiroloculina, d'Orbigny [1826], Roemer, Macgillivray, Reuss, Ehrenberg, Bornemann, Costa, Williamson, Parker and Jones, Karrer, Carpenter, Seguenza, Brady, Schwager, Robertson, Schulze, Terquem, Berthelin, Wright, &c.

In the typical *Spiroloculina* the segments are Milioline—that is to say, each extends the entire length of the shell, and the position of the aperture is alternately at either end —they are arranged on one plane, and the whole of them are visible on both sides of the test. These characters serve to distinguish it from *Miliolina*, in which the plane of growth changes with each fresh segment, and from *Biloculina*, in which, though the chambers are arranged symmetrically on one plane, they are broad and embracing, and each encloses all the previous segments on the same side.

But whilst these are typical characters, and in most cases sufficient for the discrimination of the subgeneric groups, they are open to considerable variation. For example, in

Spiroloculina it is not uncommon to find specimens of which the central portion is somewhat thicker than the remainder of the shell, which is the result of a non-symmetrical or *Miliolina*-like arrangement of the earliest segments. Deep-sea specimens of *Spiroloculina tenuis* are often in this condition. Sometimes the successive chambers embrace the preceding ones on the same side, in part or almost entirely, and the test becomes slightly concave, whilst retaining otherwise its nearly symmetrical contour. Lastly, there are certain forms in which the later segments individually occupy less than one-half of a convolution, and these lead by insensible degrees to the genus *Hauerina*. Such intermediate conditions are a frequent source of difficulty to the systematist, though they furnish interesting links connecting the subordinate types.

The genus *Spiroloculina* most affects the shallow margins of temperate and tropical seas. From the littoral zone to a depth of five or six hundred fathoms it is comparatively abundant, but at greater depths the number of species diminishes, and beyond a thousand fathoms only the small thin variety (*Spiroloculina tenuis*) is usually met with. It makes its first appearance, geologically, in the Lower Lias clays of Warwickshire (Parker and Jones); it is found in the Middle Lias of Essey-lès-Nancy (Terquem and Berthelin); in the Upper Lias of the neighbourhood of Banbury (Walford), and subsequently in microzoic strata of almost every age.

Spiroloculina planulata, Lamarck, sp. (Pl. IX. fig. 11, *a.b.*).

"Frumentaria *Sigma* et *Rhombos*," Soldani, 1795, Testaceographia, vol. i., part 3, p. 299, pl. clv. fig. *kk*.

Miliolites planulata, Lamarck, 1805, Ann. du Muséum, vol. v. p. 352, No. 4.—1822, Anim. s. Vert., vol. vii. p. 613, No. 4.

Miliola planulata, Defrance, 1824, Dict. Sci. Nat., vol. xxi. p. 68.

Spiroloculina depressa, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 298, No. 1.—Modèle, No. 92.

„ *badenensis*, Id., 1846, For. Foss. Vien., p. 270, pl. xvi. figs. 13–15.

„ *dilatata*, Id. Ibid., p. 271, pl. xvi. figs. 16–18.

„ *depressa*, var. *rotundata*, Williamson, 1858, Rec. For. Gt. Brit., p. 82, pl. vii. fig. 178.

„ *planulata*, Jones, Parker and Brady, 1866, Foram. Crag, p. 15, pl. iii. figs. 37, 38.

In dividing the *Spiroloculinæ* into specific or varietal groups Parker and Jones adopt Lamarck's name, as the earliest, for the simple complanate forms with non-limbate sutures and without surface-ornament. To this "species" they refer the *Spiroloculina depressa* of d'Orbigny (Modèle, No. 92) and the *Spiroloculina depressa*, var. *rotundata* of Williamson. The specimen figured by the latter author as the typical *Spiroloculina depressa* is referred by them to *Spiroloculina limbata*, d'Orbigny.

I am not prepared to suggest any better mode of treatment. Any lines of separation

between the successive modifications fail of application when the number of specimens is large,—*Spiroloculina planulata*, *Spiroloculina nitida*, *Spiroloculina limbata*, *Spiroloculina impressa*, *Spiroloculina excavata*, and others, are but successive terms of a series in which every intermediate link can be supplied. Under these circumstances the distribution of each variety as distinct from its congeners must be taken with much reservation.

The geographical range of the typical *Spiroloculina planulata* is very wide. It is abundant on our own shores, and is a common organism in littoral and shallow-water sands in temperate regions generally. It is not found in Arctic latitudes, and in the tropics its place is often occupied by closely allied varieties, such as *Spiroloculina nitida*. It is not at home in deep water, nevertheless Parker and Jones mention "rare" specimens in two soundings from the North Atlantic below 2000 fathoms.

What appears to be a feeble modification of the species has been met with in the Lower Lias; and well-marked specimens occur from time to time, in company with other *Miliolæ*, in Tertiary deposits, from those of the Paris Basin (Louvres and Grignon) to the Crag of the eastern counties of England and the Pliocene of Italy.

Spiroloculina nitida, d'Orbigny (Pl. IX. figs. 9, 10).

"Frumentaria *Sigma* et *Rhombos*," Soldani, 1795, Testaceographia, vol. i., part 3, p. 230, pl. clv. figs. *ll. mm.*

Spiroloculina nitida, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 298, No. 4.

„ „ Parker, Jones and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 248, pl. viii. fig. 24.

Soldani's drawing (*loc. cit.*, fig. *ll.*), named by d'Orbigny *Spiroloculina nitida*, appears to be intended for one of the varieties of *Spiroloculina planulata* which differs from the typical form in its discrete or slightly inflated segments and the somewhat produced superior extremity of the final chamber. The complanate shallow-water *Spiroloculinæ* of the tropics are very variable in minor characters, but a considerable section of them, well typified by the figures Pl. IX. figs. 9, 10, may be assigned to this particular form.

Spiroloculina nitida is common in the coral-sands of the Indian and Pacific Oceans and of the Red Sea; it occurs also in the Inland Sea of Japan, in the Mediterranean, and elsewhere.

Soldani appears to have obtained the species from the Italian Tertiaries, as well as in the recent condition.

Spiroloculina fragilissima, n. sp. (Pl. IX. figs. 12–14).

Test nearly circular, complanate, extremely thin; peripheral edge rounded. Segments numerous, much curved, the later ones in adult specimens nearly semicircular. Shell-wall

delicately thin and opalescent, the sutures appearing as conspicuous white lines. Aperture cribrate. Diameter, $\frac{1}{30}$th inch (0·8 mm.).

This is a very well-marked intermediate form, which may be classed either amongst *Hauerinæ* or *Spiroloculinæ* with almost equal propriety. The cribrate aperture is a common character of *Hauerina*, but it is also an occasional feature of *Miliolina*. On the other hand, though the length of the segments is sometimes irregular, there are never more than two in each convolution, so that their general arrangement is that of *Spiroloculina*. In short, it may be regarded either as a *Spiroloculina* with porous aperture, or as a *Hauerina* with abnormally long segments; and whichever view be adopted, it supplies an interesting connecting link between the two genera.

Spiroloculina fragilissima is a rare coral-reef species. It occurs in two soundings off Tahiti, Society Islands, at 420 fathoms and 620 fathoms respectively; off Kandavu, Fiji Islands, 255 fathoms; at two Stations on the south coast of Papua, 3 to 28 fathoms, and at two points on the north coast of the same island, 16 to 25 fathoms.

Spiroloculina robusta, n. sp. (Pl. IX. figs. 7, 8).

Test oblong or oval, with angular or pointed extremities, compressed or complanate; broad and thick, slightly concave on both faces, rounded at the periphery. Segments few in number, much arched; the inner margin of each overlapping a considerable portion of the previous segment on the same side, their lateral surfaces crested by angular ridges. Length, $\frac{1}{10}$th inch (2·5 mm.).

A very large fine species, found in the rich dredging off Culebra Island, West Indies, 390 fathoms.

Spiroloculina limbata, d'Orbigny (Pl. IX. figs. 15–17;—Var. Pl. X. figs. 1, 2).

"Frumentaria *Sigma* et *Rhombos*," Soldani, 1798, Testaceographia, vol. ii. p. 54, pl. xix. fig. *m*.
Spiroloculina limbata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 299, No. 12.
" " Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesell., vol. vii. p. 348, pl. xix. fig. 1, *a*, *b*.
" *depressa*, Williamson, 1858, Rec. For. Gt. Brit., p. 82, pl. vii. fig. 177.
Miliola (*Spiroloculina*) *limbata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 409, pl. xvii. fig. 83, *a*, *b*.
Spiroloculina depressa, Terquem, 1875, Anim. sur la Plage de Dunkerque, p. 38, pl. v. fig. 18.

The Soldanian figure on which d'Orbigny founded this species is far from satisfactory, but the name has been generally accepted for those Spiroloculine forms which have limbate sutural lines and square periphery. Bornemann's figure, *loc. cit.*, represents an excellent typical specimen from the Septaria-clay of Hermsdorf, just such an one as might be found living on our own coast at the present day. Prof. Williamson, and following

him, M. Terquem, figure distinctly limbate specimens under the name of *Spiroloculina depressa*; but d'Orbigny's model of the latter species has no sutural limbation, and appears to be the same as the *Spiroloculina planulata* of Lamarck. The illustrations presented in Pl. IX. figs. 15–17 are taken from what appear to me good typical examples of the limbate form.

A few specimens of somewhat thinner contour and more delicately made, shown in Pl. X. figs. 1, 2, occur in one of the Challenger dredgings in shallow water, off the southern coast of Papua. On the strength of their distinctly limbate septal lines I have classed them provisionally as a variety of this species, notwithstanding their comparative tenuity and their flat instead of somewhat concave lateral surfaces.

Spiroloculina limbata occurs in all the great oceans, as well as in the Mediterranean and the Red Sea. It is commonest in shallow water, but is tolerably frequent to a depth of 400 fathoms; beyond that it becomes rare, and except at one Station off the north coast of Papua (1070 fathoms) it has not been met with at greater depth than 700 fathoms.

It is found as a Tertiary fossil in the Septaria-clay of North Germany (Bornemann), in the Pliocene marls of Italy (Soldani, d'Orbigny) and Sicily (Jones and Parker), and in the Glacial Clays of Norway (M. Sars), and of the north-east of Ireland (Wright).

Spiroloculina excavata, d'Orbigny (Pl. IX. figs. 5, 6).

Spiroloculina excavata, d'Orbigny, 1846, For. Foss. Vien., p. 271, pl. xvi. figs. 19–21.
„ „ Brady, 1865, Nat. Hist. Trans. Northd. and Durham, vol. i. p. 93, pl. xii. fig. 1.
„ „ Terquem, 1875, Anim. sur la Plage de Dunkerque, p. 38, pl. v. fig. 17, *a*, *b*.

This species may be briefly characterised as having thick edges and deeply sunk centre. The most "excavated" specimens take the somewhat elongate contour represented in the drawings, and have the final segment extending a little beyond the rest of the shell. Such forms must be sought chiefly in the shallow water surrounding the coral islands of the Pacific. D'Orbigny's figure is taken from the broader variety, which, in the living condition, is not uncommon amongst the *Miliolæ* of temperate latitudes.

Spiroloculina excavata is very widely distributed, but it does not extend into the colder seas beyond the temperate zones, nor are the specimens usually very abundant. It is at home in shallow water, rarely exceeding 100 fathoms, but specimens have been found in one locality at a depth of 420 fathoms.

D'Orbigny's fossil specimens were from the Miocene beds of Baden in the Vienna Basin.

Spiroloculina impressa, Terquem (Pl. X. figs. 3, 4).

Spiroloculina impressa, Terquem, 1878, Mém. Soc. géol. Fr., sér. 3, vol. i. p. 53, pl. x. fig. 8

In his memoir on the Foraminifera and Ostracoda of the Upper Pliocene of the Island of Rhodes, M. Terquem figures two *Spiroloculinæ*, very much alike in their general features, with the names *Spiroloculina grateloupi* and *Spiroloculina impressa* (*op. cit.*,

pl. x. figs. 5, 6 and 8). They seem to be mere varieties of *Spiroloculina limbata*, somewhat narrower and flatter than the typical form, not so strongly nor so regularly limbate over the septal lines, and with the ends of the chambers projecting a little beyond the rest of the shell. Prof. Parker gives a drawing of what appears to be the same form in his paper on the Miliolitidæ of the Indian Seas (Trans. Micr. Soc. Lond., 1858, vol. vi., pl. v. fig. 3), but simply describes it as a "*Spiroloculina* with square cells and produced edges," without appending any trivial name.

Specimens similar to these have been met with in the Challenger material from two or three points in the eastern seas; namely, off Amboyna, 15 to 50 fathoms; Philippine Islands, 95 fathoms; and Humboldt Bay, Papua, 37 fathoms.

Spiroloculina tenuis, Czjzek, sp. (Pl. X. figs. 7–11).

Quinqueloculina tenuis, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 149, pl. xiii. figs. 31–34.
„ „ Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 385, pl. l. fig. 8, *a*, *b*, *c*.
Spiroloculina rostrata, Id. Ibid., p. 382, pl. xlix. fig. 7.
„ *tenuissima*, Reuss, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 71, pl. i. fig. 11.
„ *berchtoldsdorfensis*, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 375, pl. xvi. *a*. fig. 10.
Quinqueloculina tenuis, Siddall, 1878, Proc. Chester Soc. Nat. Sci., part ii., p. 46.

Spiroloculina tenuis presents a certain degree of variability of contour, caused by occasional irregularity in the disposition of the central chambers. In small delicate specimens the test is commonly Spiroloculine from beginning to end, but those of larger size have often a thickened centre, owing to the earlier segments not being arranged on one plane, but more or less on the Quinqueloculine plan, as shown in the section, fig. 11. It is probably due to this fact that the species has been sometimes assigned to the genus *Quinqueloculina;* but a slight irregularity in the young condition is of little morphological importance when compared with the unmistakably Spiroloculine characters of the mature shell.

Spiroloculina tenuis inhabits all the great ocean basins. It is especially abundant in the South Pacific, north-west of Juan Fernandez (Stations 296–302), and the specimens are relatively large. It appears less common in the North Pacific than elsewhere. It occurs at every depth from the shallow water of our own shores down to 2750 fathoms, the finest specimens being from moderately deep bottoms.

The fossil specimens figured by Czjzek, Reuss, and Karrer, are from beds of Tertiary age at various localities within the Austrian Empire.

Spiroloculina asperula, Karrer (Pl. VIII. figs. 13, 14, and 11 ?).

Spiroloculina asperula, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 136, pl. i. fig. 10.

I have met with two varieties of this species having morphological characters practi-

cally identical, but strikingly different in point of size. Dr. Karrer, in his memoir on the Miocene Foraminifera of Kostej in the Banat, *loc. cit.*, accurately describes the smaller of these, which is represented by fig. 14, as resembling *Spiroloculina tenuis* in general form, but having a rough, sandy exterior. The recent specimens, however, are often even smaller than those of the smooth-shelled species alluded to, $\frac{1}{65}$th inch (0·4 mm.) being about their average length. The larger variety (fig. 13), on the other hand, sometimes attains a length of $\frac{1}{9}$th inch (3·0 mm.), and is proportionately broad.

The two varieties are found in similar localities, in comparatively shallow water in the tropics, as follows :—Admiralty Islands, at two Stations, 16–25 fathoms ; Ki Islands, 129 fathoms ; Humboldt Bay, Papua, 37 fathoms ; Philippine Islands, 95 fathoms.

A few specimens of a form having intermediate characters (Pl. VIII. fig. 11), related apparently to both *Spiroloculina asperula* and *Spiroloculina arenaria*, have been met with in much deeper water (542 fathoms), in one of the " Porcupine " dredgings in the warm area of the Faröe Channel. These are retained provisionally under the present species, but it is possible they may represent a complanate or outspread variety of *Miliolina agglutinans*, which in its typical condition is not uncommon in the same area.

Spiroloculina arenaria, n. sp. (Pl. VIII. fig. 12).

Test oblong or oval, complanate ; extremities obtusely angular or slightly rounded, peripheral edge rounded ; segments few and broad, indistinct externally. Aperture small, circular, with Milioline tongue ; situated in a slightly produced shelly neck. Exterior sandy ; length, $\frac{1}{15}$th inch (1·7 mm.).

This species is distinguished from *Spiroloculina asperula* by its stouter proportions, the comparatively small number of its segments, and their relatively greater width. The septation is obscured by the sandy texture of the test, but as far as can be judged from the exterior, the two segments forming the peripheral whorl each occupy about one-third of the entire width of the shell.

Spiroloculina arenaria occurs at three of the Challenger Stations, namely, off Kandavu, Fiji Islands, 210 fathoms ; off Raine Island, Torres Strait, 185 fathoms ; and amongst the Philippine Islands, 95 fathoms.

Spiroloculina tenuiseptata, n. sp. (Pl. X. figs. 5, 6).

Test complanate, elongate-oval ; extremities tapering, subangular, peripheral edge square or rounded. Segments numerous, narrow, arched, tubular ; the successive convolutions separated by deep depressions on both sides of the test, the interspace being occupied by a thin horizontal, shelly septum, which is sometimes wanting between the later chambers. Aperture simple, circular. Length, $\frac{1}{22}$nd inch (1·2 mm.).

The test of *Spiroloculina tenuiseptata* resembles at first sight that of *Spiroloculina limbata*, but in reality the conditions are exactly reversed, that is to say, the raised portions of the surface represent the chambers, and the intervening depressions the shelly septa. M. Terquem has figured a *Spirillina* (or *Cornuspira*?) with the same peculiarity developed to an even greater degree under the name *Spirillina lateseptata*,[1] in which a thin, broad, horizontal plate separates the successive convolutions of the spire. In the present species the width of the septa varies a good deal, and it is not uncommon to find a small portion of the final segment left unattached at its inner margin. In one minute specimen (fig. 6) the thin shelly plate, which is unusually broad in the earlier portion of the test, is incomplete; and the later segments are entirely free and separated from the previous convolutions by an open space.

In the recent condition *Spiroloculina tenuiseptata* is a rare form, only found hitherto at three localities :—off Ki Islands, 580 fathoms; off Kandavu, Fiji, 610 fathoms; and the Mediterranean, 1200 fathoms.

One or more of the specimens figured in von Schlicht's work on the Foraminifera of the Septaria-clay of Pietzpuhl, pl. xxxvii. fig. 27, &c., named by Reuss *Spiroloculina dorsata*, appear to belong to this species.

Spiroloculina acutimargo, n. sp. (Pl. X. figs. 12–15).

Test oval, complanate, thin, slightly convex on both sides; peripheral margin acute or carinate, extremities obtuse or slightly rounded. Chambers arcuate, angular or carinate at the outer margin, either slightly embracing or separated by the intervening wing of the previous convolutions. Aperture small, sometimes in a produced tubular extension of the final segment. Length, $\frac{1}{30}$th inch (0·85 mm.).

Referring to Plate X.—figures 12 and 13 represent fully-grown typical examples of this species; fig. 14, an immature shell; and fig. 15, which is taken from one of comparatively large size, an old and worn specimen of the same. Amongst those forms of *Spiroloculina* that have the aperture in a produced neck, instances are by no means rare in which the shell is perforated at intervals on the median line, little open spaces being left at the ends of the segments, especially in the later convolutions. This condition, which is easily accounted for, is shown in fig. 15 to a somewhat marked degree, and it may often be observed, though to a less extent, in specimens of *Spiroloculina grata* (fig. 16 of the same plate).

Spiroloculina acutimargo has been dredged off Bermuda at a depth of 435 fathoms; at four Stations in the South Atlantic, 350 to 1425 fathoms; and at three localities in the South Pacific, 15 to 255 fathoms; it has also been found in shore-sands collected on the east coast of Madagascar.

[1] Anim. sur la plage de Dunkerque, pl. i. fig. 6.

Spiroloculina grata, Terquem (Pl. X. figs. 16, 17, 22, 23).

Spiroloculina grata, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i. p. 55, pl. x. figs. 14, 15.

The figures of *Spiroloculina grata* in Terquem's memoir on the Foraminifera of the Upper Pliocene beds of the island of Rhodes, represent with tolerable accuracy the thin striate *Spiroloculinæ* not uncommon in coral detritus. The surface-ornamentation of these specimens is often irregular and the lines more or less oblique; and the final segment is generally extended so as to form a tubular neck.

This species is common on coral-reefs, even to depths of 400 or 500 fathoms. Of twelve recorded localities only one is in the western hemisphere,—off Bermuda 435 fathoms. It occurs in shallow-water in the Red Sea, and is abundant in a gathering of shore-sand from the east coast of Madagascar, the specimens being of large size; the remaining localities are all in the neighbourhood of the islands of the Pacific.

As above indicated, it was originally described from fossil specimens obtained from the later Tertiaries of the island of Rhodes.

Spiroloculina antillarum, d'Orbigny (Pl. X. fig. 21, *a.b.*).

Spiroloculina antillarum, d'Orbigny, 1839, Foram. Cuba, p. 149, pl. xi. figs. 3, 4.

Under this name d'Orbigny figures a somewhat heavy, biconvex, striate *Spiroloculina*, found by him in the shore-sands of Cuba. Whether it is worth while to separate such forms from the other striate varieties of the same genus may be open to question. The drawing on Pl. X., which is taken from a Challenger specimen, pretty accurately represents the characters of the original figure in the "Cuba" monograph.

Spiroloculina antillarum has been observed only at one Station, No. 122, in the South Atlantic, off Pernambuco, 350 fathoms.

Spiroloculina (?) *convexiuscula*, n. sp. (Pl. X. figs. 18–20).

Test compressed, broadly elliptical or nearly circular, slightly biconvex; peripheral edge sharp or carinate; lateral surfaces marked by partial, irregular, longitudinal costæ. Segments few in number, broad, embracing; septation obscure externally. Aperture placed somewhat at one side of the median peripheral line; oval, bordered by a thickened or everted lip. Long diameter rarely more than $\frac{1}{50}$th inch (0·5 mm.).

It is difficult to say to which of the Milioline genera this pretty little species may with most propriety be assigned. At first sight it has the appearance of the young or immature condition of some larger species, but its very constant characters and its distribution alike forbid this supposition. In many specimens the broad embracing chambers of the final convolution completely enclose all the preceding ones, a condition which suggests affinity with a section of the genus *Biloculina*, characterised by compression in a direction contrary to the normal or typical plan. But this is not an invariable feature, and the

form of orifice is very distinct from that of any known member of that genus; indeed the position of the aperture and the occasional asymmetry of the shell, so far as they go, indicate a relationship with the genus *Miliolina*. The general contour of the test and its many points of resemblance to *Spiroloculina acutimargo* probably furnish on the whole the safest guide, and it has therefore been placed provisionally amongst *Spiroloculinæ*.

Spiroloculina convexiuscula has only been met with in material from two localities, both of them on the coast of Papua—one to the south, in Torres Strait, 155 fathoms, the other on the north, off the Admiralty Islands, 16 to 25 fathoms.

Spiroloculina crenata, Karrer (Pl. X. figs. 24–26).

Spiroloculina crenata, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 135, pl. i. fig. 9.

This beautiful little shell, first described by Dr. Karrer from fossil specimens found in the rich Miocene deposit of Kostej in the Banat, is not uncommon amongst coral-sands. Its occurrence has been notified at about a dozen localities, chiefly amongst the reefs surrounding the islands of the Pacific, at various depths from 12 to 610 fathoms; also off Bermuda, 435 fathoms, and from the littoral sand of the eastern shores of Madagascar.

Miliolina, Williamson.

Serpula, pars, Linné [1758], Walker and Jacob, Adams, Maton and Rackett, Dillwyn.
Vermiculum, pars, Montagu [1803], Fleming, Macgillivray, Thorpe.
Miliolites, pars, Lamarck [1804], Parkinson.
Miliola, pars, Lamarck [1804], Parkinson, Defrance, Blainville, Schultze, Egger, Parker and Jones, Carpenter, &c.
Pollonites, Montfort [1808].
Triloculina, *Quinqueloculina*, d'Orbigny [1826], Brown, Roemer, Reuss, Bailey, Bornemann, Costa, Terquem, Parker and Jones, Karrer, Carpenter, Seguenza, M. Sars, Hantken, &c.
Adelosina, d'Orbigny [1826], Brown, Reuss, Karrer, Terquem, Berthelin.
Cruciloculina, d'Orbigny [1839].
Miliolina, Williamson [1858], M. Sars, Alcock, Parfitt, Whiteaves, Brady, Siddall, Terrigi, Wright.

For reasons already given I prefer to treat the Triloculine and Quinqueloculine *Miliolæ* as a single sub-generic group, with the zoological characters laid down by Prof. Williamson, slightly modified as follows:—"Shell free; convoluted; inequilateral; usually oblong; consisting of numerous segments, each of which in turn extends over the entire length of the shell. Convolutions not disposed in the same plane, but constantly changing their direction, so that parts of from three to six [or in rare cases as many as eight] visible segments contribute in various proportions to form the external surface of the shell. Septal orifice large, alternately occupying opposite extremities of the shell [almost invariably] furnished with an appendicular tooth [rarely multiple or porous]."

The alterations I have ventured to make are placed in brackets. They are

designed to include certain species differing from most of their congeners either in the number of visible segments or in the character of the orifice. Such aberrant varieties as *Miliolina triquetra* are necessarily disregarded in the construction of a generic definition.

Miliolina seminulum, Linné, sp. (Pl. V. fig. 6, *a.b.c.*).

"Conchula minima arcte in se contorta, &c." Plancus, 1739, De Conch. min. not., p. 19, pl. ii. fig. 1, *A*, *B*, *C*.

"Tubulus marinus inregulariter intortus vermicularis," Gaultieri, 1742, Index Testarum, pl. x. fig. *s*.

Serpula seminulum, Linné, 1767, Syst. Nat., 12th ed., p. 1264, No. 791;—1788, 13th (Gmelin's) ed., p. 3739, No. 2.

"Frumentaria *seminula*," Soldani, 1795, Testaceographia, vol. i., part 3, p. 228, pl. clii. figs. *A*, *B*.

Serpula ovalis, Adams, 1800, Trans. Linn. Soc. Lond., vol. v. p. 4, pl. i. figs. 28–30.

Vermiculum intortum, Montagu, 1803, Test. Brit., p. 502.

„ „ Fleming, 1822, Mem. Wern. Nat. Hist. Soc., vol. iv. p. 564, pl. xv. fig. 3.

Quinqueloculina lævigata, d'Orbigny, 1826, Ann Sci. Nat., vol. vii. p. 301, No. 6.

„ *aspera*, Id. Ibid. p. 301, No. 11.

„ *triangularis*, Id. Ibid. p. 302, No. 34.

„ *seminulum*, Id. Ibid. p. 303, No. 44.

„ *lævigata*, Id. 1839, Foram. Canaries, p. 143, pl. iii. figs. 31–33.

„ *meridionalis* (pars), d'Orbigny, 1839, Foram. Amér. Mérid., p. 75, pl. iv. figs. 1–3.

„ *isabellei*, Id. Ibid. p. 74, pl. iv. figs. 17–19.

„ *araucana*, Id. Ibid. p. 76, pl. ix. figs. 13–15.

„ *magellanica*, Id. Ibid. p. 77, pl. ix. figs. 19–21.

„ *hauerina*, Id. 1846, For. Foss. Vien., p. 286, pl. xvii. figs. 25–27.

„ *mayeriana*, Id. Ibid. p. 287, pl. xviii. figs. 1–3.

„ *triangularis*, Id. Ibid. p. 288, pl. xviii. figs. 7–9.

„ *akneriana*, Id. Ibid. p. 290, pl. xviii. figs. 16–21.

„ *regularis*, Reuss, 1849, Denkschr. d. k. Akad. Wien, vol. i. p. 384, pl. l. fig. 1, *a.b.c.*

„ *concinna*, Id. Ibid. p. 384, pl. l. fig. 2, *a.b.c.*

„ *impressa*, Id. 1851, Zeitschr. d. deutsch. geol. Gesell., vol. iii. p. 87, pl. vii. fig. 59, *a.b.c.*

„ *occidentalis*, Bailey, 1851, Smithsonian Contrib., vol. ii. art 3, p. 13, figs. 46–48.

„ *ermani*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesell., vol. vii. p. 353, pl. xix. fig. 6, *a.b.c.*

„ *cognata*, Id. Ibid. p. 352, pl. xix. fig. 7, *a.b.c.*

„ *impressa*, Id. Ibid. p. 352, pl. xix. fig. 8, *a.b.c.*

„ *ovalis*, Id. Ibid. p. 353, pl. xix. fig. 9, *a.b.c.*

Miliolina seminulum, Williamson, 1858, Rec. For. Gt. Br., p. 85, pl. vii. figs. 183–185.

Quinqueloculina lamellidens, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 41, pl. i. fig. 7.

„ *ludwigi*, Id. 1866, Denkschr. d. k. Akad. Wien, vol. xxv. p. 126, pl. i. fig. 12.

„ *seminulum*, Jones, Parker, and Brady, 1866, Foram. Crag, p. 9. pl. iii. figs. 35, 36.

„ *triangularis*, Id. Ibid. p. 10, pl. iv. fig. 1.

„ *ovula*, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 147, pl. ii. fig. 8.

„ *semilunum*, Terquem, 1875, Anim. sur la Plage de Dunkerque, fasc. i. p. 40, pl. vi. fig. 8.

„ *oblonga*, Id. Ibid. p. 40, pl. vi. fig. 10.

„ *pauperata*, Id. Ibid. p. 40, pl. vi. fig. 11.

„ *akneriana*, Id. 1876, Ibid. fasc. ii. p. 85, pl. xii. fig. 5.

„ *plana*, Id. 1878, Mém. Soc. géol. Fr., sér. 3, vol. i. p. 63, pl. xi. fig. 6.

„ *vulgaris*, Id. Ibid. p. 66, pl. xi. fig. 20–21.

The name *Miliolina* or *Quinqueloculina seminulum* is one that has been almost universally adopted by English authors for the typical smooth-shelled *Miliola* with five visible segments. As a specific term, however, it has not met with the same acceptance amongst Continental rhizopodists. Though included by d'Orbigny in his first list of species, it never reappears in his subsequent works, nor, so far as I am aware, is the name ever employed in the memoirs of Reuss, Costa, Bornemann, Karrer, Gümbel, Stache, or Hantken. The reason may possibly lie in the fact that the description given by Linné, and the figures referred to in the works of the earlier naturalists, included too great a variety of forms to suit d'Orbigny's method of species-making; and succeeding authors found it easier to follow d'Orbigny, or to invent new names for trivial modifications not figured by him, than to trouble themselves about the comparative value of minor characters, or about precedence in nomenclature.

The following is the notice of the species in the 12th edition of the Systema Naturæ, 1767, vol. i. p. 1264 :—

"*Serpula seminulum*—791. S. testa regulari ovali libera glabra.

"*Planc. conch.*, t. ii. f. 1 ?

"*Gault. test.*, t. x. f. *s.*

"*Habitat in* M. Adriatico; *minuta.* Testa recidit a congeneribus quod libera fit nec adhæreat aliis corporibus, quamvis anfractus inter se uniti, et quod apertura in mea non conspicua."

In the 13th (Gmelin's) edition, 1788, some further particulars are supplied, together with additional references, namely, to a figure in Martini's Conchylien-Cabinet, 1769, vol. i. pl. iii. fig. 22, *a.b*, and to a description in Fabricius's Fauna Groenlandiæ, p. 376, No. 370.

The annexed woodcuts are accurate copies of the drawings referred to in the later edition.

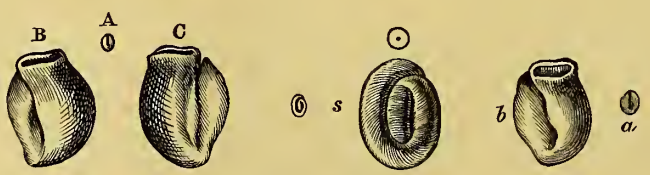

FIG. 2.—*Serpula seminulum*, Linné.

A, B, C. Copied from the figure in Plancus,—De Conch. min. not., pl. ii. fig. 1.
s. From Gaultieri,—Index Testarum, pl. x. fig. *s.*
a, b. From Martini,—Conchyl.-Cab., vol. i. pl. iii. fig. 22.

There is sufficient evidence that many of the earlier authors recognised, to some extent at least, the extreme variability of foraminiferal shells, and the Linnean name, as applied to a series of this sort, has in reality better right of precedence than if it had

been originally allotted to one of the minor varieties. Neither can there be any doubt that the organisms Linné had in mind when writing his description were the very common forms, for which the name has been retained by Williamson, Parker and Jones, and others in more recent times. D'Orbigny's notice of the species in the Tableau Méthodique incidentally confirms this view, inasmuch as the figures that he refers to in the works of Soldani, Adams, and Fleming, taken collectively, cover very much the same ground.

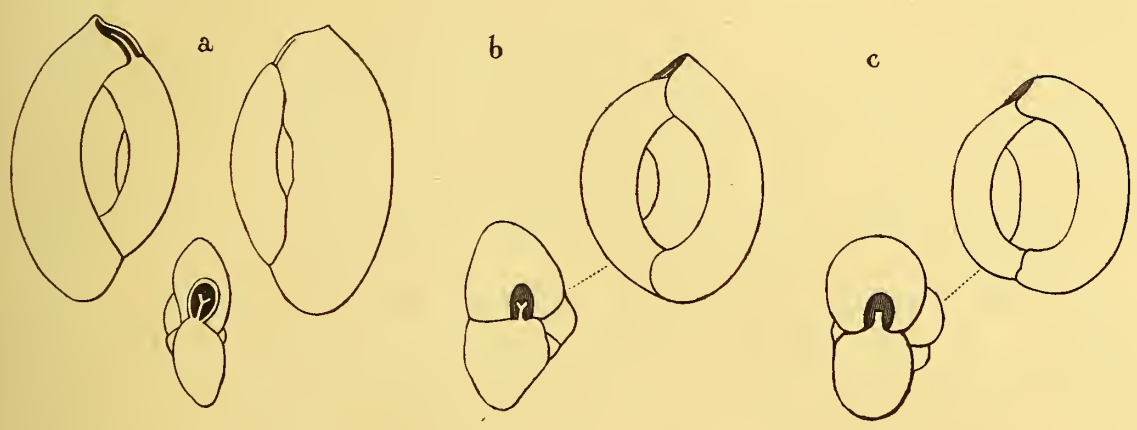

Fig. 3.—*Miliolina seminulum*, Linné, sp.

a. After Williamson, recent, British.
b. After Parker and Jones, arctic, × 15 diam.
c. Fossil, from the Crag, × 16 diam.

The foregoing woodcuts from published sources, together with the figure Pl. V. fig. 6, sufficiently indicate the range of form embraced under the Linnean name. The list of synonyms drawn up in accordance therewith is somewhat lengthy, but it might without difficulty be greatly extended. The closely allied Triloculine variety *Miliolina oblonga*, has been allotted a separate position, though it is open to doubt whether it represents anything more than the young or arrested specimens of the same species. In like manner sundry forms which have received names on account of morphological peculiarities, of no great importance in themselves but apparently of a certain local significance, have been retained, when the characters seemed sufficiently well-marked for easy recognition. Such subordinate modifications have no claim to be regarded as anything more than varieties or subvarieties.

The anomalous specimen Pl. V. fig. 15, *a.b.*, is too obviously a monstrosity to require a distinctive name. It is the largest Quinqueloculine *Miliola* met with in the Challenger material, the diameter being $\frac{1}{7}$th inch (3·75 mm.). The segments are irregularly disposed, and there are two apertures, both at the same end of the shell. It was found in material from Station 246, North Pacific, 2050 fathoms.

Miliolina seminulum is common to every latitude, from the furthest points of the Arctic Seas yet explored to the equator, and from the equator to the Antarctic ice-barrier; and to every depth from the shallowest shore-pool down to 3000 fathoms.

The geological distribution of the typical form possibly does not extend further back than the Eocene beds of the neighbourhood of Paris (Grignon) and the London Clay, but from that time forward the species is met with in marine deposits of almost every age.

Miliolina oblonga, Montagu, sp. (Pl. V. fig. 4, *a.b.*).

Vermiculum oblongum, Montagu, 1803, Test. Brit., p. 522, pl. xiv. fig. 9.
Triloculina oblonga, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 300, No. 16; Modèle, No. 95.
,, *chemnitizana*, Id. 1839, Foram. Canaries, p. 141, pl. iii. figs. 19–21.
,, *oblonga*, Id. 1839, Foram. Cuba, p. 155, pl. x. figs. 3–5.
Miliolina seminulum, var. *oblonga*, Williamson, 1858, Rec. For. Gt. Br., p. 86, pl. vii. figs. 186, 187.
Miliola (*Quinqueloculina*) *oblonga*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 411, pl. xv. figs. 34–41; pl. xvii. figs. 85, 86.
Miliolina oblonga, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 173, pl. i. fig. 2.

This is a feeble smooth-shelled variety of *Miliolina*, commonly Triloculine in the arrangement of its chambers, but often becoming Quinqueloculine in its later stages. The specimen from which the figure has been engraved is perhaps not one of the most characteristic, though it nearly resembles the drawing in the "Cuba" monograph. Williamson (*loc. cit.*) gives an excellent representation of the long typical form in its Triloculine condition; and d'Orbigny one of intermediate proportions, under the name *Triloculina chemnitziana*. Another intermediate is figured by the latter author as *Triloculina planciana* (Foram. Cuba, pl. ix. figs. 17–19), the only difference being its slightly rugose surface.

Miliolina oblonga occurs in every part of the world, almost irrespective of latitude or depth. Fine specimens, however, are to be looked for in the shallow water of temperate seas, and are nowhere more frequent than on our own coast.

As a fossil it is a common constituent of marine deposits as far back as the Eocene period.

Miliolina gracilis, d'Orbigny, sp. (Pl. V. fig. 3, *a.b.c.*).

Triloculina gracilis, d'Orbigny, 1839, Foram. Cuba, p. 159, pl. xi. figs. 10–12.

This little organism cannot be regarded as anything more than a starved varietal or subvarietal modification of *Miliolina oblonga*, from which it differs chiefly in the spreading phialine lip surrounding the aperture. The connecting links between the two are to be found in such forms as *Triloculina nitida*, Foram. Canaries, p. 141, pl. iii. figs. 22–24. The striation of the shell, though shown in d'Orbigny's figure, is too faint and irregular to be a character of much importance, nor is it uniformly present. D'Orbigny assigns

the species to *Triloculina* in the text of the "Cuba" monograph, to *Quinqueloculina* on the plate, a sufficient evidence of its variability. Under the name *Quinqueloculina angustissima* (Denkschr. d. k. Akad. Wiss., vol. i. p. 384, pl. xlix. fig. 18), Prof. Reuss describes a Miocene variety of similar feeble habit, which except in being somewhat thinner, differs but little in contour from the recent form.

The Challenger specimens of *Miliolina gracilis* are from Humboldt Bay, Papua, 37 fathoms; those described by d'Orbigny were found in shore-sands from Cuba and Jamaica.

Miliolina cultrata, H. B. Brady (Pl. V. figs. 1, 2).

Miliolina cultrata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S. p. 45.

Test Triloculine, depressed; segments long, narrow, biconvex; superior end of the final chamber projecting far beyond the base of the penultimate; peripheral margin furnished with a continuous narrow keel or wing. Length, $\frac{1}{30}$th inch (0·8 mm.).

Miliolina cultrata is a thin feeble form with conspicuous marginal keel. The figured specimens are from Humboldt Bay, Papua, 37 fathoms. Some fine examples, many of them rather more broadly built than these, have been found in sand dredged by Mr. A. Haly, off Calpentyn, Ceylon, 2 fathoms. I am not aware of any other locality for the species.

Miliolina valvularis, Reuss, sp. (Pl. IV. figs. 4, 5).

Triloculina valvularis, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesell., vol. iii. p. 85, pl. vii. fig. 56.
,, *lævigata*, Bornemann, 1855, Ibid. vol. vii. p. 350, pl. xix. fig. 5.

I have adopted Reuss's name for some striking Triloculine *Miliolæ* dredged off the coast of New Zealand. They agree accurately in general characters with the engravings referred to in the memoir on the Foraminifera of the Septaria-clays of the neighbourhood of Berlin, and differ only in the shape of the mouth, which, instead of being a semicircular slit, is long and irregularly bent, the lips puckered and closely drawn together. The test is large, some of the specimens being more than $\frac{1}{10}$th inch (2·5 mm.) in length, and very compactly built; the inner marginal edges of the chambers thin out and embrace the adjoining segments. The disposition of the segments and the unusual thickness of the shell-wall are well shown in the section (fig. 5). The species is one of the few that may rank with *Miliolina trigonula* and *Miliolina tricarinata* as a true *Triloculina*.

The Challenger specimens are from Station 168, north-east coast of New Zealand, depth 1100 fathoms.

The fossil examples figured by Reuss and by Bornemann are from the Tertiary Septaria-clays of Hermsdorf, near Berlin.

Miliolina venusta, Karrer, sp. (Pl. V. figs. 5, 7).

Quinqueloculina venusta, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 147, pl. ii. fig. 6.

This variety is more distinct and more easily recognised than may appear from the figures. Its long oval shape, the subcarinate margins of the three outermost segments, and the slightly produced and truncate oral end of the final chamber, are characters which, though not of much value individually, serve very well for its identification.

It is essentially a deep-water form. Out of a list of fourteen Stations, twelve have depths ranging from 1800 to 2700 fathoms, the localities being pretty evenly distributed over the North and South Atlantic and the North and South Pacific.

Dr. Karrer's figure is from a fossil specimen, from the Miocene of Kostej in the Banat.

Miliolina auberiana, d'Orbigny, sp. (Pl. V. figs. 8, 9).

Quinqueloculina auberiana, d'Orbigny, 1839, Foram. Cuba, p. 167, pl. xii. figs. 1–3.
„ *ungeriana*, Id. 1846, For. Foss. Vien., p. 291, pl. xviii. figs. 22–24.

A large, heavy, more or less triangular variety, differing from the typical *Miliolina seminulum* in its broad contour, and in the margins of the segments being acutely angular, as shown in the transverse section (fig. 9), instead of being in some degree rounded.

Such forms are somewhat widely diffused and are occasionally found at considerable depths. The distribution appears to be as follows :—North Atlantic, south-west of Ireland, 2435 fathoms ; West Indies, off Culebra Island, 390 fathoms, and the west coast of Patagonia, 245 fathoms. D'Orbigny's specimens were from the shores of Cuba and Martinique, and Max Schultze has figured the same or a closely allied form from the Adriatic.

Judging from d'Orbigny's figures of *Quinqueloculina ungeriana* and *Quinqueloculina akneriana*, which are the connecting links between the present variety and *Quinqueloculina seminulum*, it may be assumed that *Miliolina auberiana* is to be found also in the Miocene beds of the Vienna Basin.

Miliolina cuvieriana, d'Orbigny, sp. (Pl. V. fig. 12, *a.b.c.*).

Quinqueloculina cuvieriana, d'Orbigny, 1839, Foram. Cuba, p. 164, pl. xi. figs. 19–21.
„ *lamarckiana*, Id. Ibid. p. 164, pl. xi. figs. 14, 15.

The *Quinqueloculina cuvieriana* of the " Cuba " monograph is a smooth-shelled variety, in which the peripheral margins of all the five visible segments are sharp or subcarinate. Its peculiarities are identical with those of *Quinqueloculina lamarckiana*, figured by d'Orbigny on the same plate, and differ very slightly from those of the variety last described, *Quinqueloculina auberiana*.

The Challenger specimens are from five localities, one of which is the Inland Sea, Japan, the remainder at various points in the Eastern Archipelago, the coast of Papua, and the Philippine Islands, the depths ranging from 6 to 95 fathoms. Those figured by d'Orbigny were from the shores of Cuba and Jamaica.

Miliolina pygmæa, Reuss, sp. (Pl. CXIII. fig. 16, *a.b.*).

Quinqueloculina pygmæa, Reuss, 1850, Denkschr. d. k. Akad. Wien, vol. i. p. 384, pl. l. fig. 3, *a. b.*
„ *lucida*, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 147, pl. ii. fig. 7.

There is great difficulty in selecting a trivial name, out of the multitude that present themselves, for any varietal form of *Miliola* not endowed with surface ornament to assist in its identification. I think, however, I cannot be wrong in assigning to *Quinqueloculina pygmæa*, Reuss, a number of specimens characterised by long, narrow, distinct, and subcylindrical segments. The thicker specimens sometimes have more than five chambers visible externally, whilst the smaller ones betray a tendency to grow thin and almost Spiroloculine. Many of the recent shells closely resemble Dr. Karrer's *Quinqueloculina lucida*, and furnish connecting links, both in point of size and morphological features, between the drawings of that form and Prof. Reuss's type.

I have found *Miliolina pygmæa* at ten of the Challenger Stations, of which seven are amongst the island groups of the Southern Pacific, and of the western coast of South America, the remaining three being—south of Japan, Hong Kong Harbour, and Vigo Bay, respectively; but it is a small inconspicuous organism that may have been overlooked in other localities. Though occasionally found in shallow water, it affects somewhat greater depths than most of the *Miliolinæ*, and one-half of the localities are set down at more than 170 fathoms, the deepest being 580 fathoms.

The memoirs of Reuss and Karrer above referred to give the species a place amongst Miocene Rhizopoda.

Miliolina amygdaloides, n. sp. (Pl. VI. fig. 10, *a.b.*).

Test compressed, elongate-oval with tapering ends; one face nearly flat, the other convex and subangular; periphery sharp. Surface smooth, no external constrictions marking the margins of the chambers. Segments numerous, long and narrow; aperture circular, produced. Shell-wall thin and opalescent. Length, $\frac{1}{50}$th inch (0·5 mm.) or less.

This is a minute species but very uniform in its adult characters. The shell is exceedingly neatly made, but owing to the flush sutures the segmentation is always obscure. I know of no previously described form with which the specimens can properly be associated, the *Quinqueloculina pygmæa* of Reuss is perhaps the nearest, but the rounded chambers, excavated sutures, and generally larger size sufficiently distinguish that from the present species.

The distribution, so far as apparent from the Challenger material, is confined to bottoms of moderate depth in the neighbourhood of some of the islands of the Pacific, such as the *Hyalonema* ground, south of Japan, 345 fathoms; off the Ki Islands, 580 fathoms; and at a couple of Stations amongst the islands on the west coast of Patagonia, 565 fathoms and 147 fathoms respectively.

Miliolina trigonula, Lamarck, sp. (Pl. III. figs. 14–16).

Miliolites trigonula, Lamarck, 1804, Ann. du Mus., vol. v. p. 351, No. 3;—1822, Anim. s. Vert., vol. vii. p. 612, No. 3.
„ *cor-anguinum*, Id. 1804, Ann. du Mus., vol. v. p. 351, No. 2;—1822, Anim. s. Vert. vol. vii. p. 612, No. 2.
„ „ Blainville, 1825, Man. de Malac., p. 369, pl. iv. fig. 3, *a.b.*
Triloculina trigonula, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 299, No. 1, pl. xvi. figs. 5–9;—Modèle, No. 93.
„ *globulus*, Id. 1839, Foram. Amér. Mérid., p. 71, pl. ix. figs. 9, 10.
„ *austriaca*, Id. 1846, For. Foss. Vien., p. 275, pl. xvi. figs. 25–27.
Miliola austriaca, Egger, 1857, Neues Jahrb. für Min., &c., p. 271, pl. vi. figs. 4–6.
Miliolina trigonula, Williamson, 1858, Rec. For. Gt. Br., p. 83, pl. vii. figs. 180–182.
(?) *Biloculina lucernula*, "triloculine variety," Schwager, 1866, Novara-Exped., Geol. Theil., vol. ii. p. 202, pl. iv. fig. 14, *a.b.*
Miliola trigonula, Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 386, No. 2.

There are few members of the Milioline group so constant even in their minor characters as *Miliolina trigonula*. The shell is regularly Triloculine, subspherical or oblong, and nearly circular in end-view. Nevertheless, if a large series be collected, a few specimens will generally be found amongst them, like fig. 14 (Pl. III.), which by the comparatively small exposure of the third segment attest their near relationship with the *Biloculinæ*. A shell almost identical with this in form has been figured by Dr. Schwager (*loc. cit.*) as a "Triloculine variety of *Biloculina lucernula*"; and so far as parentage, in that particular case, is concerned, there is no reason to question the diagnosis of so careful an observer; but had the specimen occurred alone, it would probably have been assigned to the present species.

On the other hand, the separation of *Miliolina trigonula* from *Miliolina tricarinata* depends solely on the comparative roundness or angularity of the three salient chamber-margins; and, as this is of necessity an exceedingly variable character, there are often to be found intermediate specimens whose affinity must be judged by the forms with which they are associated rather than by their own individual peculiarities.

Miliolina trigonula is a very widely distributed inshore species, more abundant in the temperate zones than in the tropics, but never reaching the polar seas. It is common at every part of our own coast. It has been collected at depths as great as 2300 fathoms, but well-marked specimens are rare in deep water, and beyond 100 fathoms the species is generally replaced by *Miliolina tricarinata*.

Its geological range extends throughout the Tertiary epoch. It occurs in the Eocene of the neighbourhood of Paris (Lamarck, d'Orbigny), in the Miocene of Austria and Lower Bavaria (d'Orbigny, Egger), in the Pliocene of many localities in Italy (Jones and Parker), and in the Post-tertiary beds of the West of Scotland (Robertson) and of North of Ireland (Stewart).

Miliolina insignis, H. B. Brady (Pl. IV. figs. 8, 10).

Miliolina insignis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 45.

This species has the same general contour as *Miliolina trigonula*, and the arrangement of the segments is in all respects similar, but the surface of the shell instead of being smooth is ornamented by delicate, closely set, longitudinal costæ. Some of the Atlantic specimens attain considerable dimensions and are relatively shorter and more stoutly built than the typical form. Length, $\frac{1}{17}$th inch (1·5 mm.).

Miliolina insignis has been met with at two of the Challenger Stations in the North Atlantic, namely, off Sombrero Island and off Culebra Island, West Indies, at 390 fathoms and 450 fathoms respectively; in the South Atlantic at Station 346, near the Equator, 2350 fathoms, and off Pernambuco, 350 fathoms; in Simon's Bay, Cape of Good Hope, 15 to 20 fathoms; in Bass Strait, 38 fathoms; and at one point in the deep area of the North Pacific (Station 244) 2900 fathoms. The species also occurs in shallow water on the coast of Ceylon, and Mr. Robertson's cabinet contains specimens from the coast of Java.

Miliolina tricarinata, d'Orbigny, sp. (Pl. III. fig. 17, *a.b.*).

Triloculina tricarinata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 299, No. 7;—Modèle, No. 94.
Cruciloculina triangularis, Id. 1839, Foram. Amér. Mérid., p. 72, pl. ix. figs. 11, 12.
Triloculina gibba, Id. 1846, For. Foss. Vien., p. 274, pl. xvi. figs. 22–24.
Miliola gibba, Egger, 1857, Neues Jahrb. für Min., &c., p. 271, pl. vi. figs. 1–3.
Triloculina tricarinata, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 446, pl. xlviii. fig. 3.
Miliola (*Triloculina*) *tricarinata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 409, pl. xv. fig. 40.
Triloculina tricarinata, Reuss, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 71, pl. ii. fig. 4.

This species presents the extreme development of Triloculine characters. It bears the same morphological relation to *Miliolina trigonula* that *Biloculina depressa* bears to *Biloculina ringens;* that is to say, the peripheral margin of the segments is in the one case angular or carinate, and in the other rounded. In *Biloculina depressa* the carina is formed by the free edge of the ultimate segment; in *Miliolina tricarinata* two of the angles are formed by the outermost segment and the third by the free margin of the penultimate.

The genus *Cruciloculina* was founded by d'Orbigny for a *Miliolina* with exactly the same disposition of segments, but with a cruciate aperture instead of one of the ordinary Milioline type. It is needless to say that the aperture is too variable a feature amongst the Porcellanea to be accepted by itself as a specific, still less as a generic distinction. The *Triloculina gibba* of the "Vienna Basin" monograph only differs from *Miliolina tricarinata* in its slight irregularity of contour and somewhat blunt chamber-margins.

Miliolina tricarinata has a far wider geographical distribution than its near ally

Miliolina trigonula, and is in fact a true cosmopolite. It is one of the few *Miliolæ* that were obtained from the most northerly sounding made on the last British North-Polar Expedition, in latitude 83° 19′ N.; and it was also present in the Austro-Hungarian soundings off Franz-Josef Land at about lat. 80° N. From these points southward to the Equator, and from the Equator southward to the Antarctic Ice-barrier (Station 155) it is found in every sea, and its bathymetrical range embraces depths varying from 6 fathoms to 2350 fathoms. It sometimes attains very large dimensions. A specimen from Station 24—off Culebra Island, West Indies, 390 fathoms—measures more than $\frac{1}{6}$th inch (4·45 mm.) in length, and some of those dredged by Mr. Whiteaves in the Gulf of St. Lawrence are of almost if not quite equal magnitude.

Its geological history is confined to the Tertiary epoch. It occurs in the Eocene beds of Grignon near Paris (Parker and Jones), in the Miocene deposits of Austria and Lower Bavaria (d'Orbigny, Reuss, Egger), in the Crag of the east of England (Jones, Parker, and Brady), in the Post-tertiary beds of Canada (Dawson), of Norway (Crosskey and Robertson), and of the west of Scotland (Robertson).

Miliolina terquemiana, n. sp. (Pl. CXIV. fig. 1, *a.b.*).

Test elongate, tapering towards both ends, triangular; salient edges sharp or subcarinate. Segments broad, the outer faces convex; disposed on the Triloculine plan; aperture subtriangular, with long appendicular tooth. Surface ornamented with fine parallel longitudinal costæ. Length, $\frac{1}{50}$th inch (0·5 mm.).

The general characters of this shell are those of *Miliolina tricarinata*, with the addition of the costate surface ornament. It is perhaps no more than a varietal modification, though quite distinct from the other striate and costate *Miliolæ*. It has been named in honour of the veteran French rhizopodist M. Terquem.

Miliolna terquemiana is exceedingly rare. Hitherto I have only seen specimens from two localities, namely, in shallow-water sand, dredged off Calpentyn, Ceylon, and in littoral sand from the east coast of Madagascar.

Miliolina bertheliniana, n. sp. (Pl. CXIV. fig. 2, *a.b.*).

Test elongate, tapering at both ends, triangular; salient edges sharp or subcarinate. Segments disposed in Triloculine manner, broad, convex externally; surface decorated with an embossed reticulation. Aperture large, subtriangular or rounded, furnished with the Milioline tooth. Length, $\frac{1}{66}$th inch (0·4 mm.).

This little shell may be regarded as a variety of *Miliolina tricarinata*, which it resembles in all respects except the surface ornamentation. I have much pleasure in

naming so pretty an organism after one of the most assiduous of French rhizopodists, M. Berthelin.

Miliolina bertheliniana is exceedingly rare, its known distribution being confined to four localities, namely:—off Ascension Island, 7 fathoms; off Calpentyn, Ceylon, 2 fathoms; and in shore-sands collected by Mr. Kitching near Tamatavé, Madagascar, and near Port Elizabeth, Algoa Bay.

Miliolina secans, d'Orbigny, sp. (Pl. VI. figs. 1, 2).

"Frumentaria *seminula*," Soldani, 1795, Testaceographia, vol. i. part 3, p. 228, pl. clii. fig. *E*.
Quinqueloculina secans, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 303, No. 43;—Modèle, No. 96.
„ *vulgaris*, Id. Ibid. p. 302, No. 33.
„ *planciana*, Id. 1839, Foram. Cuba, p. 162, pl. x. figs. 24, 25.
„ *cora*, Id. 1839, Foram. Amér. Mérid., p. 76, pl. ix. figs. 16–18.
„ *haidingerii*, d'Orbigny, 1846, For. Foss. Vien., p. 289, pl. xviii. figs. 13–15.
Miliolina seminulum, var. *disciformis*, Williamson, 1858, Rec. For. Gt. Br., p. 88, pl. vii. figs. 188, 189.
Quinqueloculina secans, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 34, pl. i. fig. 10.

The d'Orbignian model of *Quinqueloculina secans* is an excellent typical representative of a group of *Miliolinæ* characterised by their broad, compressed, outspread contour and sharp or subcarinate peripheral edge. Similar forms appear in successive works under many different names, and the foregoing list of synonyms might be much extended were that desirable.

Miliolina secans is a very common species, frequenting the shallow-water margins of the seas of both temperate and tropical latitudes. It is found in shelly sand from every part of our own coast, and is especially abundant in the Mediterranean, where the specimens often attain very large dimensions.

In the fossil condition it occurs in the Miocene of the Vienna Basin (d'Orbigny, Reuss), in the later Tertiary clays of Italy and Sicily (Jones and Parker), and in the Post-tertiary deposits of the west of Scotland (Robertson) and of the north-east of Ireland (Wright). A variety of the same species, with partially serrate margin, from the Italian Tertiaries, is figured by Prof. Costa under the name of *Quinqueloculina denticulata* (Atti dell' Accad. Pont., vol. vii. p. 325, pl. xxv. fig. 6).

Miliolina macilenta, n. sp. (Pl. VII. figs. 5, 6).

Test complanate, oval or discoidal; margin thin; resembling *Miliolina secans* in general contour and habit, but having a surface-ornament of curved, parallel, longitudinal or somewhat obliquely-set costæ. Length, $\frac{1}{40}$th inch (0·6 mm.).

This appears clearly to be a costate variety of *Miliolina secans*, which hitherto has remained unnoticed. It occurs at three Stations amongst the islands of the Pacific,

namely, Nares Harbour, Admiralty Islands, 17 fathoms; Humboldt Bay, Papua, 37 fathoms; and off Honolulu, Sandwich Islands, 40 fathoms.

Miliolina subrotunda, Montagu, sp. (Pl. V. figs. 10, 11).

"Serpula subrotunda dorso elevato" Walker and Boys, 1784, Test. Min., p. 2, pl. i. fig. 4.
Vermiculum subrotundum, Montagu, 1803, Test. Brit., part 2, p. 521.
,, ,, Fleming, 1823, Mem. Wern. Nat. Hist. Soc., vol. iv. p. 565, pl. xv. fig. 5.
Quinqueloculina subrotunda, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 302, No. 36.
,, *dilatata*, Id. 1839, Foram. Cuba, p. 166, pl. xi. figs. 28–30.
,, *meridionalis*, Id. 1839, Foram. Amér. Mérid., p. 75, pl. iv. figs. 1–3, 10–13.
Triloculina truncata, Karrer, 1864, Sitzungsb. d. k. Ak. Wiss. Wien., vol. l. p. 704, pl. i. fig. 2.
Miliola (*Quinqueloculina*) *subrotunda*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 411, pl. xv. fig. 38.
Quinqueloculina subrotunda, Brady, 1865, Nat. Hist. Trans. Northd. and Dur., vol. i. p. 94, pl. xii. fig. 2.
Triloculina dilatata, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 139, pl. ii. fig. 1.
Miliola subrotunda, Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 386, No. 4.
Quinqueloculina orbicularis, Terquem, 1876, Anim. sur la Plage de Dunkerque, fasc. ii., p. 86, pl. xii. fig. 9, *a.b.*

The characters of *Miliolina subrotunda* may be stated in very few words. The shell is either Triloculine or Quinqueloculine, broad, compressed, and suborbicular, and the peripheral margin is thick and rounded. It is subject to irregularity both in the shape and disposition of the segments, and in the form of the aperture, which in well-grown examples has generally a conspicuous Milioline tooth; but the general aspect of the shell answers to the foregoing description. Fleming (*loc. cit.*) states that the (visible) "chambers are three sometimes four in number, inflated and wrinkled," and that "the fourth chamber when present seems always imperfectly formed," by which he means shorter than normal; and he gives an excellent figure of the species in this condition, taking on the Hauerine mode of growth. Such specimens are common in shallow water on our own coast, and have sometimes been confused with true *Hauerinæ*. Its more regular varieties resemble *Miliolina secans* in their broad discoidal contour; but the inflated chambers and thick rounded margin are sufficiently distinctive when contrasted with the sharp peripheral edge of the latter species.

It would require a large series of figures to represent adequately the individual modifications of this form, but the illustrations referred to in the foregoing synonymy serve collectively to give a general idea of its various aspects. The drawings (Pl. V. figs. 10, 11) are from South Atlantic specimens, off Tristan d'Acunha, 100 to 150 fathoms. The shell figured by Messrs. Parker and Jones (*loc. cit.*) is from the Arctic seas; and the remainder of the list includes specimens from the British and French coasts, the West Indies, and South America, in every case from shallow water or from littoral sand.

The fossil Triloculine specimens described by Dr. Karrer are from the Miocene of the Vienna Basin and of the Banat. The species occurs also in the Crag of Suffolk.

Miliolina fichteliana, d'Orbigny, sp. (Pl. IV. fig. 9, *a.b.c.*).

Triloculina fichteliana, d'Orbigny, 1839, Foram. Cuba, p. 152, pl. ix. figs. 8–10.
„ *suborbicularis*, Id. Ibid. p. 156, pl. x. figs. 9–11.
„ *webbiana*, Id. 1839, Foram. Canaries, p. 140, pl. iii. figs. 13–15.

The three d'Orbignian species above referred to represent striate varieties of *Miliolina subrotunda*. They are all Triloculine *Miliolæ* of the broad outspread type, with more or less inflated chambers and rounded periphery, and present a similar surface-ornament of fine parallel longitudinal lines. They differ somewhat amongst themselves in minor particulars, but within limits similar to those recognised in the case of the unornamented species. The figured shell resembles most the drawings of *Triloculina webbiana*, but there are many specimens, even in the same dredging, in which the breadth of the final segment and the size of the aperture are less conspicuous features.

In addition to the littoral sands of the West Indies and the Canary Islands (the localities given by d'Orbigny), *Miliolina fichteliana* occurs in similar material from Madagascar, in dredged sand from the Inland Sea of Japan, 14 fathoms, and from the Chinese Sea.

Miliolina circularis, Bornemann, sp. (Pl. IV. fig. 3, *a.b.c*; and Pl. V. figs. 13, 14 ?).

Triloculina circularis, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesell., vol. vii. p. 349, pl. xix. fig. 4

I doubt very much whether there is any constant or reliable distinction between the *Triloculina circularis* of Bornemann and *Miliolina subrotunda*, and whether any good purpose is served by endeavouring to retain both species. The original figure of the former portrays a thicker and more tumid shell than *Miliolina subrotunda*, the final segment being especially convex and embracing; and the aperture is a simple crescentiform slit. Its claim for recognition depends on these two characters alone.

Specimens corresponding to this description have been found at three Challenger Stations:—off Prince Edward's Island, 50 to 150 fathoms; off Christmas Harbour, Kerguelen Islands, 120 fathoms; and Bass Strait, 38 fathoms.

Those originally described by Bornemann were Tertiary fossils from the Septaria-clay of Hermsdorf, near Berlin.

Miliolina circularis, var. *sublineata*, nov. (Pl. IV. fig. 7, *a. b.c.*).

Similar in general contour, disposition of segments, form of aperture and dimensions to *Miliolina circularis*. Shell thin and often sub-translucent; decorated with a surface ornament of delicate, interrupted, longitudinal striæ.

I have only met with the substriate variety in one locality—off the Admiralty Islands, on the north coast of New Guinea, 15 to 25 fathoms.

Miliolina labiosa, d'Orbigny, sp. (Pl. VI. figs. 3–5).

Triloculina labiosa, d'Orbigny, 1839, Foram. Cuba, p. 157, pl. x. figs. 12–14.

The *Triloculina labiosa* of d'Orbigny embodies a group of *Miliolæ* presenting somewhat anomalous characters. The segments are few in number, inflated, and irregularly disposed; the aperture is arched or crescentiform, and has a thickened lip. Such forms furnish the connecting links between *Miliola* and *Nubecularia*. The less irregular varieties show a tendency to become more and more definitely Milioline in the arrangement of their segments, and can scarcely be distinguished from *Miliolina subrotunda;* whilst the most aberrant are only separable from *Nubecularia inflata* by the possession of a single terminal aperture in place of numerous orifices scattered over the body of the shell.

But perhaps the most interesting point in connection with this species is the occurrence of specimens, especially of the more regular varieties approaching *Miliolina subrotunda* in contour, in the deepest water of the North Pacific. As has been already stated, the Milioline shells obtained from the abyssal area are usually extremely thin, insomuch that they occasionally collapse on being taken out of fluid and allowed to dry; and in some instances they are so completely siliceous that they bear the action of strong acids without alteration. In such cases the texture is homogeneous and translucent, and scarcely differs in appearance from the young condition of a porcellanous shell.

I have note of the occurrence of *Miliolina labiosa* at sixteen Challenger Stations, of which seven are in the deep area of the North Pacific already referred to, the depth ranging from 2050 to 3950 fathoms: the remainder are chiefly in shallow water at various points of the southern hemisphere. A striate variety of the species is found on the shores of Ceylon.

Miliolina bucculenta, n. sp. (Pl. CXIV. fig. 3, *a.b.*).

Miliola (*Triloculina*) *cryptella*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 410, pl. xv. 39, *a.b.*

Test subglobular, more or less compressed, the two sides nearly symmetrical, margin lobulated; segments inflated, broad and embracing, the last three forming a single convolution, which completely encloses the preceding ones. Aperture a long, irregularly arched, transverse slit, on the face of the terminal segment, near the line of union with the previous convolution. Diameter, $\frac{1}{12}$th inch (2 mm.).

This is a somewhat anomalous species in whatever light it is regarded. It is a Triloculine *Miliola*, with a planospiral manner of growth; or a *Planispirina* without the alar flaps which cause the lamination of the shell characteristic of that genus; or a swollen *Hauerina* without a cribrate aperture. Its nearest allies, however, appear to be such

forms as *Triloculina circularis*, Bornemann, and *Triloculina valvularis*, Reuss, and it presents fewest difficulties treated as an aberrant modification of *Miliolina*. Parker and Jones (*loc. cit.*) figure an arctic specimen with almost identical characters under the name *Miliola* (*Triloculina*) *cryptella*. But the *Triloculina cryptella* of d'Orbigny (Foram. Amér. Mérid., p. 70, pl. ix. figs. 4, 5) appears to be a very distinct form, the shell of which, though subglobose in contour, is constructed on the normal Milioline plan, two segments to each convolution; I have therefore included the specimens referred to in the present species.

I am only aware of the occurrence of the typical *Miliolina bucculenta* at three localities, all of them in the North Atlantic. The figured shell is from the Faröe Channel, 630 fathoms, Messrs. Parker and Jones's specimens were from Baffin's Bay, and in the Rev. A. M. Norman's cabinet there are excellent examples dredged during the "Valorous" Expedition, 1785 fathoms.

Miliolina bucculenta, var. *placentiformis*, nov. (Pl. IV. figs. 1, 2).

Test asymmetrical; irregularly oval or nearly circular in contour, much compressed; peripheral edge thick and rounded. Segments broad, irregular, and embracing; the final convolution, consisting of two to three chambers, entirely enclosing the preceding whorls. Aperture either a long, narrow, curved, transverse slit, or a crescentic opening near the inner margin of the last segment. Longer diameter, $\frac{1}{12}$th inch (2 mm.).

This variety differs from the typical form in its general asymmetry, its flattened contour, and the irregularity of the shape of its segments. The ultimate segment occupies about one-half of the visible shell, the penultimate about three-fourths of the remainder, whilst the antepenultimate is but little exposed owing to the partial overlap of its predecessors.

Miliolina bucculenta, var. *placentiformis*, has been collected in two localities, namely, off Culebra Island, West Indies, 390 fathoms; and Balfour Bay, Kerguelen Islands, 20 to 50 fathoms.

Miliolina bicornis, Walker and Jacob, sp. (Pl. VI. figs. 9, 11, 12).

"Serpula bicornis ventricosa," Walker and Boys, 1784, Test. Min., p. 1, pl. i. fig. 2.
"Frumentaria *fœniculum*," Soldani, 1795, Testaceographia, vol. i. part 3, p. 229, pl. cliv. figs. *bb. cc.*
Serpula bicornis, Walker and Jacob, 1798, Adams's Essays, Kanmacher's ed., p. 633, pl. xiv. fig. 2.
Triloculina brongniartii, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 300, No. 23.
Quinqueloculina guancha, Id. 1839, Foram. Canaries, p. 143, pl. iii. figs. 34–36.
„ *flexuosa*, Id. 1839, Foram. Amér. Mérid., p. 73, pl. iv. figs. 4–6.
„ *striolata*, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 385, pl. l. fig. 10, *a.d.*
„ *affinis*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 329, pl. xxv. fig. 13.

Miliolina bicornis, Williamson, 1858, Rec. For. Gt. Br., p. 87, pl. vii. figs. 190–192.
Quinqueloculina brongniartii, Jones, Parker, and Brady, 1866, Foram. Crag, p. 14, pl. iii. figs. 41, 42.
Triloculina brongniartii, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 250, pl. viii. fig. 9.
Quinqueloculina quinquangularis, Terquem, 1878, Mém. Soc. géol. Fr., sér. 3, vol. i. p. 74, pl. xiv. figs. 1, 2.
„ *intricata*, Id. Ibid. p. 73, pl. xiii. figs. 16–21.

Of the decorated varieties of *Miliolina*, those with a surface-ornament of raised lines constitute by far the largest proportion. The lines vary in thickness, number, and regularity; in some cases they form very numerous, exceedingly delicate, striæ, in others they appear as a few stout ribs; they are usually longitudinal and nearly parallel, but often run into sinuate, oblique, zigzag, branching, or reticulated forms.

Between the delicately striate and the coarsely ribbed *Miliolinæ* it is impossible to draw any fixed distinction, inasmuch as the thickness and substance of the linear ornament varies with almost every specimen; and it is equally hopeless to attempt to sort either the striate or the costate forms into subordinate groups of any real zoological value. A few varieties may be disposed of by referring them to the smooth-shelled species having the same general contour; thus, *Miliolina fichteliana* may be regarded as the striate variety of the smooth-shelled *Miliolina subrotunda; Miliolina macilenta* stands in the same relation to *Miliolina secans, Miliolina insignis* to *Miliolina trigonula*, and *Miliolina terquemiana* to *Miliolina tricarinata*. Probably this method of treatment might be carried further, but there would still remain a large number of specimens having linear ornament, but without special morphological characters by which they could be associated with any of the well-known unornamented species. As a matter of convenience, therefore, the varieties with fine longitudinal striæ not otherwise provided for, may be arranged round a single type, such as *Miliolina bicornis* or *Miliolina brongniartii*, whilst those with stout costæ find a central representative in *Miliolina pulchella*.

Which of the two former names is adopted for the striate group does not greatly matter. If we follow Prof. Williamson's interpretation of the somewhat enigmatical figure in Walker and Boys' work, and accept the excellent drawings which he gives (*loc. cit.*) in place of it, the trivial name *bicornis* must take precedence. The *Triloculina brongniartii* of the "Tableau Méthodique," has a similar linear ornament, but the figures in the "Testaceographia" on which it was founded are distinctly Quinqueloculine, and differ in no appreciable way from those already referred to in Williamson's monograph. The small Triloculine form which d'Orbigny subsequently named *Triloculina brongniartiana* (Foram. Cuba) may belong to the same species, but, if so, the drawing represents an immature shell.

The synonymy which is given above refers only to a few out of a very large number of named and figured "species" that may properly be included under the term *Miliolina bicornis*. There are certain other striate and costate forms which occur in the collections

under notice, sufficiently distinct in general contour to rank as local varieties, and as such they have been treated separately.

The distribution of *Miliolina bicornis* is exceedingly wide, but confined to the temperate and tropical zones; and no more characteristic specimens are to be found than those from our own coast. Like most of its congeners it affects shallow water—from shore-pools to a depth of 40 or 50 fathoms; in rare cases as low as 120 fathoms.

In the fossil condition good representatives of the species are recorded, under one name or other, in marine deposits of almost every age, from the Miocene epoch to the present time.

Miliolina boueana, d'Orbigny, sp. (Pl. VII. fig. 13, *a.b.c.*).

Triloculina brongniartiana (?), d'Orbigny, 1839, Foram. Cuba, p. 156, pl. x. figs. 6–8.
Quinqueloculina boueana, Id. 1846, For. Foss. Vien., p. 293, pl. xix. figs. 7–9.
„ *nussdorfensis*, Id. Ibid. p. 295. pl. xix. figs. 13–15.
Triloculina striatella, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien., vol. lvii. p. 140, pl. ii. fig. 2.
Quinqueloculina costata, Terquem, 1878, Mém. Soc. géol. Fr., sér. 3, vol. iii. p. 63, pl. vi. figs. 3, 5.

Miliolina boueana is nothing more than a compact and regular variety of *Miliolina bicornis*, with distinct and neatly rounded segments. *Quinqueloculina nussdorfensis* of the "Vienna Basin" memoir is the same, with characters a little nearer *Miliolina bicornis* itself; indeed the figures of the species given by Costa (Atti dell' Accad. Pont. vol. vii., pl. xxv. fig. 11) are distinctly referable to the typical form. *Triloculina brongniartiana*, d'Orbigny, and *Triloculina striatella*, Karrer, appear to me to be only young examples, in a Triloculine condition, of the species under notice.

The distribution of *Miliolina boueana* is probably coextensive with that of *Miliolina bicornis*.

Miliolina scrobiculata, n. sp. (Pl. CXIII. fig. 15, *a.b.c.*).

Test usually Triloculine; elliptical, compressed, margin rounded. Segments neatly and evenly fitted so that the end view is of long oval contour. Mouth a long, narrow, oval fissure, occupying almost the entire width of the final segment, surrounded by a thickened lip. Surface longitudinally striate. Length, $\frac{1}{40}$th inch (0·63 mm.).

Though *Miliolina scrobiculata* is probably only a local variety of *Miliolina bicornis*, the specimens possess remarkably uniform characters. All that have been met with are Triloculine, and have the flattened and rounded contour and elongated mouth delineated in the figures.

In a batch of sand collected on the shore at Tamatavé, Madagascar, it is a not uncommon form, and except for a few examples from one of the Challenger Stations (Nares Harbour, 17 fathoms), this is the only point at which its occurrence has been noted.

Miliolina pulchella, d'Orbigny, sp. (Pl. VI. figs. 13, 14, Pl. III. figs. 10–13).

" Frumentaria *Seminula*," &c., Soldani, 1798, Testaceographia, vol. ii. p. 53, pl. xviii. fig. *f*.
Quinqueloculina pulchella, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 303, No. 42.
,, *schreibersii*, Id. 1846, For. Foss. Vien., p. 296, pl. xix. figs. 22–24.
,, *plicosa*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 322, pl. xxv. figs. 2, 5.
,, *pulchella*, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 250, pl. viii. fig. 19.
,, ,, Terquem, 1878, Mém. Soc. géol. Fr., sér. 3, vol. i. p. 68, pl. xii. figs. 11–14.

The bold, somewhat irregular Quinqueloculine *Miliolæ*, with large, more or less interrupted, longitudinal ridges and furrows, are well typified in the Soldanian figure selected by d'Orbigny as the type of *Quinqueloculina pulchella*. The species is a very variable one, and the shells have frequently a secondary ornamentation of fine longitudinal striæ, in addition to the thicker costæ. They sometimes attain a length of $\frac{1}{10}$th inch (2·5 mm.) or more. M. Terquem figures an interesting series of specimens in various conditions of growth, in his memoir on the Foraminifera of the Upper Pliocene beds of the island of Rhodes, and from these it would appear that the young *Miliolæ* figured in Pl. III. figs. 10–13 of this Report are most of them referable to the present species.

Miliolina pulchella is not uncommon amongst the large *Miliolæ* of comparatively shallow water, that is to say, at depths of less than 100 fathoms. It occurs on the northern portions of our own coast, and occasionally elsewhere in the North Atlantic, in the Mediterranean, and, more rarely, amongst the East Indian Islands.

In common with other striate and costate *Miliolæ* its geological range appears limited to the middle and later portions of the Tertiary epoch. It is found in Miocene beds of the Vienna Basin (d'Orbigny), and in the later Tertiary deposits of Italy (Soldani, Costa), of Sicily (Jones and Parker), and of the island of Rhodes (Terquem).

Miliolina linnæana, d'Orbigny, sp. (Pl. VI. figs. 15–20).

Triloculina linnæana, d'Orbigny, 1839, Foram. Cuba, p. 153 pl. ix. figs. 11–13.
Quinqueloculina josephina, Id. 1846, For. Foss. Vien., p. 297, pl. xix. figs. 25–27.
,, ,, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 321, pl. xxv. fig. 4.

Under the name *Triloculina linnæana*, d'Orbigny depicts (*loc. cit.*) a modification or variety of *Miliolina pulchella*, which takes the place to a great extent of the typical form in tropical seas. It differs from *Miliolina pulchella* in its comparatively thin and outspread contour, which sometimes approaches that of *Spiroloculina*, the costæ being few, thick, and well-marked. A nearly identical form is described in the "Vienna Basin" memoir with the name *Quinqueloculina josephina*.

The Challenger collections have furnished specimens from eight Stations, all in the neighbourhood of the coral islands of the Pacific, and within the tropical zone. The same variety also occurs in the littoral sands of Madagascar and of the West Indies.

If my view of the figures of the fossil specimens above referred to be correct, the geological distribution of the species extends to the Nussdorf beds of the Vienna Basin (d'Orbigny), and the Tertiary clay of S. Alesandro in the island of Ischia (Costa).

Miliolina separans, H. B. Brady (Pl. VII. figs. 1–4).

Miliolina separans, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 45.

Test irregular in form, angular, outspread ; consisting of several long, slightly inflated, strongly costate, Milioline segments. The earlier portion of the test arranged on the normal Triloculine or Quinqueloculine plan, the later segments more or less free and disposed centrifugally, that is to say, at irregular angles, as though in process of uncoiling. Length, $\frac{1}{10}$th inch (2·5 mm.), or sometimes more.

This is an anomalous and wild-growing, rather than a really dimorphous, variety. It may be regarded morphologically as a costate form, such as *Quinqueloculina linnæana*, beginning to unroll itself, but never producing a definite series of straight segments like *Articulina*.

Of *Miliolina separans* the Challenger collections have furnished only two specimens, those figured on Pl. VII. figs. 1 and 4 ; the former from off Raine Island, Torres Strait, 155 fathoms ; the latter from a neighbouring locality somewhat to the west, namely, off Booby Island, 8 fathoms. But in a little tube of dredged sand, sent to me many years ago by the late Dr. Greville of Edinburgh, labelled "Storm Bay, Tasmania," *Miliolina separans* was the most prominent species, and the striking appearance of the specimens may be judged from figs. 2 and 3 of the same plate.

Miliolina ferussacii, d'Orbigny, sp. (Pl. CXIII. fig. 17, *a.b.*).

Quinqueloculina ferussacii, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 301, No. 18; Modèle, No. 32.
„ *berthelotiana*, Id. 1839, Foram. Canaries, p. 142, pl. iii. figs. 25–27.
„ *polygona* Id. 1839, Foram. Cuba, p. 198, pl. xii. figs. 21–23.
„ *rodolphina*, Id. 1846, For. Foss. Vien., p. 299, pl. xx. figs. 7–9.
„ *mariæ*, Id. Ibid. p. 300, pl. xx. figs. 13–15.
„ *concava*, Reuss, 1850, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 386, pl. li. fig. 2, *a.–e.*
Miliolina bicornis, var. *angulata*, Williamson, 1858, Rec. For. Gt. Br., p. 88, pl. vii. fig. 196.
Quinqueloculina ferussacii, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 24, pl. i. fig. 12.
Miliola mariæ, Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 387, No. 6.
Quinqueloculina mariæ, Terquem, 1875, Anim. sur la Plage de Dunkerque, pt. 1, p. 40, pl. vi. fig. 12, *a.b.*

It is much to be regretted that the classified catalogue of the Foraminifera in the Tableau Méthodique, which to the systematist is a sort of alphabet of the subject, is unaccompanied by any verbal descriptions of the species enumerated, and that, consequently, about one-half of the list stands as so much waste labour. Not only so, but many of the forms illustrated by models or by the drawings of earlier authors are subsequently ignored by d'Orbigny himself. The present species is one of these.

The model of *Quinqueloculina ferussacii* represents a narrow, thinnish, somewhat angular *Miliola*, with the prominent ridges of the chambers developed into distinct ribs. There are usually three or four such costæ on each face of the shell, the most striking of which are those which run down the middle of the final segment on either side, and a shorter one on the central, or antepenultimate chamber, which forms a sort of raised median line. These are the typical characters of the species, as determined from the model, and though much allowance must be made for variability, they indicate with sufficient accuracy the features of a large proportion of the specimens met with. The final segment, though generally a good deal longer than the penultimate, and produced at the oral end, is seldom so attenuated as in the specimens figured in Pl. CXIII., and the peripheral margin of the outer chambers, instead of being attenuated as shown in the figures, is often thickened and furnished with more or less distinct ribs, as drawn by Prof. Williamson (*loc. cit.*).

The geographical distribution of *Miliolina ferussacii* is very wide. Messrs. Parker and Jones mention it as one of the species found off the Hunde Islands in Baffin's Bay, it occurs sparingly on our own coast and on the shores of Belgium and France, amongst the Canary Islands and the West Indies. In the southern hemisphere its appearance has only been noted at two or three points on the coast of Australia, from one of which (Torres Strait, 155 fathoms) the figured specimen was obtained.

Its geological range extends as far back as the Eocene of the neighbourhood of Paris (d'Orbigny). It is found in the Miocene beds of Vienna (d'Orbigny, Reuss), and in the Crag of the eastern counties of England (Jones, Parker, and Brady).

Miliolina undosa, Karrer, sp. (Pl. VI. figs. 6–8).

Quinqueloculina undosa, Karrer, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 361, pl. iii. fig. 3.

This is a Quinqueloculine variety, somewhat of the "*ferussacii*" type, with the salient angles of the chambers developed into costæ, but instead of being straight and regular as in *Miliolina ferussacii*, they are sinuate and somewhat variable in thickness. In the fossil specimens described by Dr. Karrer, the undulated costæ constitute a very marked and peculiar feature, but in recent shells the prominent ridges of the segments take the form of thin sharp angles rather than actual ribs.

In some of its characters the variety represented in fig. 8 approaches more nearly to *Quinqueloculina longirostra*, d'Orbigny (For. Foss. Vien., p. 291, pl. xiii. figs. 25–27), and *Quinqueloculina lachesis*, Karrer (Sitz. d. k. Ak. Wiss., vol. lvii. p. 146, pl. ii. fig. 4), but there can be little doubt, notwithstanding the elongated neck, that it belongs to the same species. Mr. Hollick has not been quite happy in his rendering of the end view (fig. 8, *b*), which, perhaps from the specimen having been mounted obliquely, appears too compact and rounded: the shell is in fact somewhat compressed, and has angular chamber-margins.

The finest recent examples of *Miliolina undosa* which have come under my notice,

whether of the typical sort or of the variety with elongated neck, are from the Challenger Station 162, off East Moncœur Island, Bass Strait, 38 fathoms; but it occurs also on the coral-reefs of the Sandwich Islands, 40 fathoms; on the south coast of Papua, Flinders Passage, 7 fathoms; and off Ascension Island, 7 fathoms.

The original specimens were from the Upper Miocene of Lapugy, Austria.

Miliolina parkeri, H. B. Brady (Pl. VII. fig. 14).

"*Quinqueloculina* with oblique ridges," Parker, 1858, Trans. Micr. Soc. Lond., vol. vi., N. S., p. 53, pl. v. fig. 10.

Miliolina parkeri, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 46.

Test elongate, subtriangular, Quinqueloculine; peripheral margins of the segments sharp, with a tendency to become carinate; the surface of the chambers traversed by somewhat oblique transverse ridges or crenulations. Length, $\frac{1}{25}$th inch (1·0 mm.).

This form was figured by Prof. W. K. Parker in his paper on the Miliolitidæ of the East Indian Seas (*loc. cit.*), where it is simply characterised as a "*Quinqueloculina* with oblique ridges," and no distinctive name is given to it.

Figure 14 (Pl. VII.) represents a good average specimen; but the shell occasionally takes a somewhat flatter shape, and in such cases the mouth is surrounded by a spreading phialine lip, like that of *Articulina*.

Miliolina parkeri is essentially a coral-reef species. It occurs at seven Challenger Stations amongst the islands of the Pacific, and, with one exception (off Tahiti, 420 fathoms), always in shallow water. It has also been found in sand dredged off the Seychelles (E. P. Wright), off Java (Robertson), and in the Red Sea.

Miliolina transversestriata, H. B. Brady (Pl. IV. fig. 6, *a.b.c.*).

Miliolina transversestriata, Brady, 1881, Quart. Journ, Micr. Sci., vol. xxi., N. S., p. 45.

Test elongate, angular, Triloculine; segments few, their peripheral margins sharp or subcarinate, obliquely set. Surface marked by regular, parallel, transverse or diagonal riblets. Length, $\frac{1}{50}$th inch (0·5 mm.).

This is a minute species, and one that may easily be overlooked. Hitherto it has only been met with in two localities—off Raine Island, Torres Strait, 155 fathoms, and in harbour-mud from Port Louis, Mauritius.

Miliolina reticulata, d'Orbigny, sp. (Pl. IX. figs. 2–4).

"Frumentaria *reticulata*," Soldani, 1795, Testaceographia, vol. i. part 3, p. 233, pl. clix. figs. *bb*, *cc*.

Triloculina reticulata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 299, No. 9.

Quinqueloculina reticulata, Karrer, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 449, pl. ii. fig. 5, *a.c.*

" " Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 249, pl. viii. fig. 18.

The reticulated variety of surface ornamentation is not uncommon amongst the *Miliolæ*, and a considerable number of forms, in which it is the most prominent feature, have been described as distinct species, on the ground of slight differences in the shape and disposition of their segments.

The name *Triloculina reticulata* was originally applied by d'Orbigny to figures in the Testaceographia representing a somewhat broad shell with bordered margins. Such forms are not uncommon in the Mediterranean and elsewhere, and specimens recently obtained from the coast of Tripoli correspond in every particular with Soldani's drawings. In the "Cuba" monograph, d'Orbigny figures two reticulate species, *Triloculina carinata* (pl. x. figs. 15–17), and *Triloculina bicarinata* (pl. x. figs. 18–20), the former of which is bordered and carinate, and only differs from the Soldanian type in being rather longer and thinner; whilst the latter has prominent and angular segments. Dr. Karrer's Tertiary specimens, described as *Quinqueloculina reticulata* (*loc. cit.*), resemble figs. 2, 3 of Pl. IX in the rounded contour of their chambers, but they are relatively longer, and not so stoutly built.

Terquem, in his memoir on the Foraminifera of the Pliocene beds of the island of Rhodes, depicts a reticulated and bordered Milioline shell, indistinguishable from the original Soldanian form, under the name *Quinqueloculina variolata*. Lastly, the *Miliolina bertheliniana* of the present Report is a reticulate variety of *Miliolina tricarinata*.

I am not prepared to say how far it is desirable or useful to preserve distinctive names for all these trifling modifications, or indeed for any of them. The large and strongly-marked form represented in Pl. IX. figs. 2, 3, often attaining a length of $\frac{1}{14}$th of an inch or more (nearly 2 mm.), appears to me the best type of the group, and amongst the smaller and less well-grown specimens may be found intermediate forms connecting it with the bordered varieties. In this respect *Miliolina bertheliniana* stands somewhat apart from the rest.

Miliolina reticulata is a common tropical and sub-tropical shallow-water species, rarely found at depths of more than 50 fathoms. It is abundant on the coral-reefs of both the eastern and western hemispheres.

As a fossil its occurrence does not extend further back than the Miocene period.

Miliolina rupertiana, H. B. Brady (Pl. VII. figs. 7–12).

Miliolina rupertiana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 46.

Test elongate, biconvex and Triloculine in the young condition, Quinqueloculine and depressed in the adult; peripheral edge rounded, sometimes in very old specimens thin or carinate. Final segment terminating in an oval collar, either continuous and regular, or with a deep notch at each end (bilabiate), or with four equidistant notches forming a sort of cruciate aperture, or in some intermediate condition. Surface, striatopunctate;

beset with minute pits or depressions in close, regular, parallel lines extending from one end of the test to the other. Test imperforate, the pitted depressions penetrating only about half the thickness of the shell-wall. Length, $\frac{1}{13}$th inch (1·9 mm.).

This is an exceedingly interesting species, both on account of the peculiar structure of the shell-wall and the variability of the aperture.

The test is porcellanous and opaque, and the surface is marked by rows of pits, which at first sight bear considerable resemblance to perforations. The punctation, however, under ordinary circumstances, does not extend much beyond half the thickness of the shell-wall, and a transverse section of the test has the appearance represented in the annexed woodcut (fig. 4, *e.*). Occasionally, though very rarely, an old specimen may be met with, more or less distinctly perforate at prominent points of the surface; but this condition is never found except in dead and worn shells, and it is manifestly the result of subsequent erosion.

The woodcuts (fig. 4, *a*, *b*, *c*, *d*) illustrate the variability of the aperture better than any verbal description. The orifice itself is usually oval, and situated in a deep depression with a bilabiate or cruciate border, or occasionally one of intermediate form; but cases are not wanting in which the fissure follows the contour of the border, as in fig. *c*, and becomes lobulated at the margin.

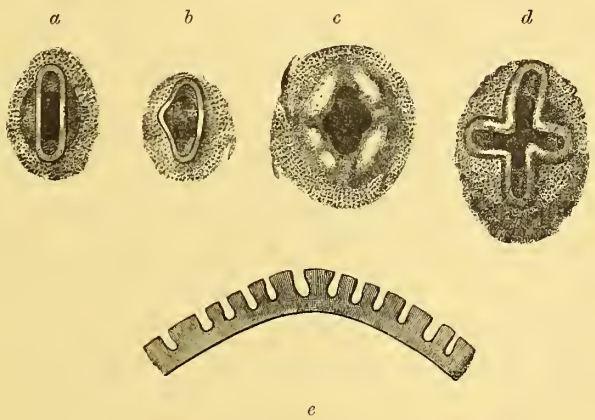

Fig. 4.—*Miliolina rupertiana.*

a. b. c. d. Various forms of aperture; magnified 40 diam.
e. Transverse section of the shell; magnified 200 diam.

The distribution of *Miliolina rupertiana* is limited to the shallow-water margins of the seas of warm latitudes. The Challenger collections only furnish specimens from the islands on the south shores of Papua, west of Torres Strait (Stations 186 to 189, depths 6 to 28 fathoms), and even here the species is very rare. It occurs in material dredged by Mr. Haly, the zealous and energetic curator of the Colombo Museum, on the north-west coast of Ceylon, 2 fathoms; in the late Mr. M'Andrew's dredgings, in the Gulf of Suez, 15 to 20 fathoms; and, much more plentifully, in littoral sands collected for me by Mr. L. Kitching, near Tamatavé, on the east coast of Madagascar.

Miliolina agglutinans, d'Orbigny, sp. (Pl. VIII. figs. 6, 7).

Quinqueloculina agglutinans, d'Orbigny, 1839, Foram. Cuba, p. 168, pl. xii. figs. 11–13.
Miliola (*Quinqueloculina*) *agglutinans*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 410, pl. xv. fig. 37, *a.b.*
Miliolina agglutinans, Siddall, 1879, Catal. Brit. Rec. Foram., p. 4.
„ „ Terrigi, 1880, Atti dell' Accad. Pontif., Ann. xxxiii. p. 172, pl. i. fig. 1.

The structure of the test of the sandy *Miliolæ* differs in one important particular from that of the strictly arenaceous groups of Foraminifera. In the *Astrorhizidæ* and *Lituolidæ* the investment is composed of sand and cement in variable proportions, and when the calcareous or other cement is in considerable excess the test is usually imperforate; when, on the other hand, the sand is coarse and the cement scanty, it becomes in a certain sense perforate, inasmuch as interstitial openings are left at various points of the surface. In the *Miliolidæ*, whether smooth or rough externally, the shell is always imperforate. The sandy coat, however thick it may be, is only an incrustation, and has a calcareous shelly lining. This inner shell is often exceedingly thin, but it appears to be invariably present; it is porcellanous in texture, and in sections presents a uniform brownish tint by transmitted light.

The arenaceous section of the *Miliolæ* includes a considerable number of specific or varietal forms, and the term *Miliolina agglutinans* is reserved for the particular group which is characterised by having the chambers arranged in the normal Triloculine or Quinqueloculine manner, and by possessing a large conspicuous aperture. These two features are sufficient to distinguish it from *Planispirina celata* and *Miliolina crassatina*, the only species with which it is likely to be confounded.

Miliolina agglutinans is a very widely diffused Foraminifer. Its area of distribution extends to all the great oceans except the South Atlantic, and includes the Mediterranean and the Red Sea. As a rule it inhabits shallow water, and is most abundant amongst the coral-sands of the tropics; but it is occasionally found at greater depths, and in one instance specimens have been obtained from the North Atlantic at 440 fathoms.

It was obtained by Crosskey and Robertson from the Post-tertiary clays of Norway, and by Robertson in those of the west of Scotland, but there appears no other satisfactory record of the occurrence of the species in the fossil condition.

Miliolina crassatina, n. sp. (Pl. VIII. fig. 5, *a.b.*).

Miliolina incrassata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 46.

Test broadly elliptical or subglobular, somewhat compressed; segments few, embracing; septation obscure. Aperture crescentic, situate in a short delicate neck rising from the superior extremity of the final segment. Texture coarsely arenaceous. Length, $\frac{1}{33}$rd inch (0·75 mm.).

There are but few external marks that afford any clue to the internal structure of the shell of this species. The segments are few in number, and, so far as can be made out, are arranged on a Triloculine or sometimes on a Biloculine plan. The general appearance of the test is that of a little oval ball of coarse sand, with a short narrow tubular neck at one end.

I find that the term "*incrassata*" which was assigned to the species when first described had been previously employed by Dr. Karrer for another member of the genus, and a slight change of name has therefore been made.

Miliolina crassatina is exceedingly rare. It has only been met with in a single dredging, off East Moncœur Island, Bass Strait, 38 fathoms, where it occurs in company with *Miliolina triquetra*, and a large assortment of non-arenaceous *Miliolæ*.

Miliolina triquetra, H. B. Brady (Pl. VIII. figs. 8–10).

Miliolina triquetra, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p 54.

Test free, compressed, sub-triangular; earlier segments combined more or less regularly in the Quinqueloculine manner, later ones spreading; the final convolution composed of three segments arranged in one plane. Aperture simple, toothed; situate in the produced neck-like extension of the terminal chamber. Texture roughly arenaceous externally. Diameter, $\frac{1}{25}$th inch (1·0 mm.).

Miliolina triquetra may be accepted as a sort of dimorphous modification of the "*agglutinans*" type, the early growth being Milioline, the later convolutions becoming planospiral, and having commonly three segments instead of two in each whorl. The drawings in Pl. VIII., and particularly that of the horizontal section fig. 10, sufficiently explain the general structure of the test.

It is a somewhat rare species, only noticed hitherto at three Challenger Stations, namely:—Bass Strait, 38 fathoms; Torres Strait, 155 fathoms; and Humboldt Bay, Papua, 37 fathoms.

Miliolina alveoliniformis, H. B. Brady (Pl. VIII. figs. 15–20).

Miliolina alveoliniformis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., 54.

Test free, elongate, fusiform; composed of narrow tubular chambers, arranged lengthwise, more or less spirally around the long axis. Segments numerous, sometimes seven or eight visible on the exterior; subcylindrical, arcuate. Aperture porous or radiate, obscure, terminal. Texture thin, porcellanous, and nearly smooth in very young shells; becoming distinctly arenaceous externally in adult specimens. Length, $\frac{1}{10}$th inch (2·5 mm.) or more.

In the structure of its test, the large fusiform *Miliola* of the coral-reefs differs equally from the normal forms with homogeneous shell-wall and smooth exterior, and the coarsely arenaceous types. Its minute texture, as shown in the longitudinal section (fig. 18), is that of a thin imperforate porcellanous layer with embedded sand-grains ; the siliceous grains being generally rather more numerous than appear in the figure, as some are unavoidably lost in process of making a section. The young shell somewhat resembles *Miliolina saxorum* in general contour, but the segments are more discrete and rounded, and even in the very early stage, whilst the surface is but slightly arenaceous, the species is easily identified. The cribrate aperture is a character of the genus *Hauerina*, rather than of the true *Miliolæ;* there are, nevertheless, important exceptions, such as *Miliolina saxorum*, Lamarck, and *Miliolina* (*Quinqueloculina*) *fabularioides*, Karrer, in which the porous condition of the orifice is a distinctive feature. In the present species the orifice is often so obscured by sand-grains as to be scarcely discernible.

Miliolina alveoliniformis is essentially a coral-reef species. So far as has been noticed hitherto, it is not very abundant in any single locality, but is of moderately frequent occurrence in littoral and shallow-water sands—that is to say, at depths of less than 50 fathoms—amongst the islands of the Pacific, in the Red Sea, and in the West Indies. That its bathymetrical range is not strictly limited to the shallower zones is indicated by the occurrence of a few specimens in a sounding from a depth of 420 fathoms, off Tahiti.

Sub-family 3. Hauerininæ.

Articulina, d'Orbigny.

Nautilus, pars, Gmelin [1788], Batsch.
Articulina, d'Orbigny [1826], Bronn, Reuss.
Vertebralina, pars, Parker, Jones, and Brady [1865], Karrer.

The genus *Articulina* comprises a group of dimorphous *Miliolæ*, in which the typical Triloculine or Quinqueloculine arrangement of the chambers prevails during early life, but subsequently gives place to a rectilinear mode of growth. The relative development of the two portions of the shell varies much more in *Articulina* than in *Vertebralina*. In certain species the linear chambers are never conspicuously developed, and the affinity can only be determined by the contour of the Milioline segments and the form of the aperture ; in some, the linear portion consists of only one or two segments ; whilst in others the test is a long *Nodosaria*-like line of chambers, in which the Milioline characters are confined to a small bulbous or knot-like swelling at the primordial end of the shell. The aperture of *Articulina* is usually situated in a deep bordered depression

on the outer face of the final segment; it is a simple rounded orifice, with or without a Milioline tongue.

The genus *Articulina* makes its appearance with the beginning of the Tertiary epoch, and is found sparingly in shallow-water deposits of middle and later Tertiary age.

Articulina sulcata, Reuss (Pl. XII. figs. 12, 13).

Articulina sulcata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 383, pl. xlix. figs. 13–17.

Prof. Reuss (*loc. cit.*) figures under the name *Articulina sulcata* a small striate Foraminifer with the general contour of *Miliolina*, that is to say, without any supplementary linear segments. In the absence of dimorphous structure, the oval aperture, the bordered septal ends of the segments and their shape are held to be sufficiently characteristic to justify the position assigned to it. The question, however, is not so much whether the figured shells belong to the genus *Articulina* as whether they are fully grown, or only one of the previously known species in its primary stage.

Recent specimens, similar in all important points to the little fossils referred to, have been obtained from some of the Challenger dredgings, and, so far as they go, they tend to confirm the view that the adult condition is reached without any change in the mode of growth. They are often of larger dimensions than the Milioline portion of *Articulina conico-articulata*, and the distribution differs considerably from that o *Articulina sagra*. In the absence of any direct evidence that they represent the young or arrested condition of either of these species, I have, with some hesitation, adopted Reuss's name for them.

Articulina sulcata is found at four Challenger Stations:—off the Bermudas, 435 fathoms; off Culebra Island, 390 fathoms; on the Honolulu coral-reefs, 40 fathoms; and off Raine Island, 155 fathoms. The somewhat similar shell with Spiroloculine contour (Pl. IX. fig. 1) was dredged off Kandavu, 255 fathoms.

The localities given by Reuss for the fossil examples are the Tertiary clays of Felsö-Lapugy in Transylvania, and of Wieliczka in Galicia.

Articulina lineata, n. sp. (Pl. XII. figs. 19–21).

Test elongate, compressed, broadly spathulate; consisting of a flat Milioline shell, surmounted by one or two rectilinear chambers. Margin thin, sharp, or slightly rounded, without any material constriction at the sutures. Surface ornamented with delicate parallel longitudinal striæ. Aperture oval, situated in the middle of the bordered slit-like depression which forms the end of the latest segment. Length, $\frac{1}{40}$th inch (0·6 mm.).

The broad, flat contour of *Articulina lineata*, its unconstricted margin, and neatly fitted segments, are well-marked characters, sufficient to distinguish it from any of its congeners.

It is a rare species, to judge by the small number of specimens hitherto found, and somewhat limited in bathymetrical range. It has been noticed at four Challenger Stations, namely:—off Kandavu, Fiji Islands, 210 fathoms and 255 fathoms; off Raine Island, Torres Strait, 155 fathoms; and in company with other varieties of the same type, off the Bermudas, 435 fathoms.

Articulina sagra, d'Orbigny (Pl. XII. figs. 22-24).

Articulina sagra,	d'Orbigny,	1839, Foram. Cuba,	p. 160, pl. ix. figs. 23–26.
Vertebralina cassis,	Id.	Ibid.	p. 72, pl. vii. figs. 14, 15.
„ *mucronata*,	Id.	Ibid.	p. 72, pl. vii. figs. 16–19.
„ „	Id.	1846, For. Foss. Vien.,	p. 120, pl. xxi. figs. 18, 19.

A comparison of a large number of specimens from various localities has led to the conclusion that the three d'Orbignian species above enumerated are only individual modifications of the same form, and that although the Milioline chambers sometimes show a tendency to open out and in so far to approach the characters of *Vertebralina*, the central or typical condition is nearly that portrayed in d'Orbigny's figure of *Articulina sagra*. It is impossible to examine side by side the drawings of *Vertebralina mucronata* in the "Cuba" or the "Vienna Basin" monograph, and those given in Pl. XII. figs. 22–24 of the present Report, without arriving at the conviction that notwithstanding the less strictly Milioline arrangement of the early segments in the d'Orbignian figures, the whole series must be referred to a single species. It appears equally clear that the drawing of *Vertebralina cassis* (*loc. cit.*) represents an immature or arrested specimen not specifically distinct from the rest.

The Milioline characters of the early chambers are readily made out in most of the specimens that have come under my notice; nevertheless, judging from d'Orbigny's figures, this portion of the shell is liable to a certain amount of variation or even of obscurity in the mode of segmentation, but the species is easily recognised in its mature state by the form of the linear segments and by the aperture.

Articulina sagra is found chiefly in coral-sands, and sometimes at considerable depths. The Challenger gatherings furnish specimens from the Honolulu Reefs, 40 fathoms; from the Friendly Islands, off Tongatabu, 18 fathoms; off Kandavu, Fiji Islands, 255 fathoms; from near Sombrero Island, West Indies, 450 fathoms; and from the Bermudas, 435 fathoms. D'Orbigny records its occurrence in littoral sands from several of the West Indian Islands

Articulina conico-articulata, Batsch, sp. (Pl. XII. figs. 17, 18; Pl. XIII. figs. 1, 2).

Nautilus (*Orthoceras*) *conico-articulatus*, Batsch, 1791, Conchyl. des Seesandes, p. 3, pl. iii. fig. 11.
Articulina nitida, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 300, No. 1—Modèle, No. 22.
Vertebralina conico-articulata, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 22, pl. i. fig. 2.
Vertebralina (*Articulina*) *elongata*, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lviii. p. 155, pl. iii. fig. 10.

There appears at first sight a wide distinction between the shells represented in Pl. XII. fig. 17 and Pl. XIII. fig. 1, but it is in reality little more than a difference in the number of linear segments, unaccompanied by any change of morphological characters; and the comparative frequency of intermediate specimens leaves no doubt that they both belong to the same species. It is rare to find the *Dentalina*-like form of so great a length relatively as the latter figure; but the number of chambers, whether two or three more or less, is nothing more than an individual peculiarity. Referring to published illustrations, Batsch's figure of *Nautilus conico-articulatus*, d'Orbigny's model of *Articulina nitida*, and Karrer's drawing of *Vertebralina elongata*, all contribute to the series of connecting links between the longer and shorter varieties of the species. The cylindrical contour and discrete segments of the linear portion of the shell, together with the rounded and bordered orifice, serve to distinguish *Articulina conico-articulata* from the other members of the genus.

The geographical distribution of *Articulina conico-articulata* is very similar to that of *Vertebralina striata*. It is at home in the seas of warm latitudes, especially amongst coral-sands, and is scarcely to be met with north of the Mediterranean. Its bathymetrical range is somewhat greater than that of the *Vertebralinæ*, and extends to 400 or 500 fathoms in the West Indies, and to an even greater depth in the Mediterranean, but in the latter case the specimens are poor and small.

The geological history of the species goes back to near the beginning of the Tertiary epoch. The habitat originally given by d'Orbigny was the Tertiary beds of the neighbourhood of Paris; Parker and Jones record its occurrence in a marl of Eocene age at Baljik in Bulgaria, and Karrer's specimens were from the Miocene of Kostej in the Banat.

Articulina funalis, n. sp. (Pl. XIII. figs. 6–11)

Test elongate, cylindrical, somewhat tapering Milioline segments few and small, forming collectively a little inflated or bulbous projection at the narrower end of the shell; linear portion very long, more or less arched or irregularly bent, composed of numerous segments combined so as to leave no external constriction at the sutures; segments cylindrical, gradually increasing in diameter, variable in length. Shell delicately thin, opalescent in young specimens; surface ornamented by fine, parallel, longitudinal striæ. Aperture simple, formed of the open, or only slightly constricted end of the terminal chamber. Length, nearly $\frac{1}{10}$th inch (2·4 mm.).

This beautiful species is more likely to be confounded with the Spiroline varieties of *Peneroplis* than with any of its more immediate allies, but it may be readily distinguished by the earlier chambers, which take the form of a little irregular oval knot instead of being symmetrically coiled in one plane. Its even unconstricted outline and flush sutures afford a further means of diagnosis. Prof. Costa, in the Paleontologia del regno di Napoli (p. 225, pl. xx. fig. 2, *A.B.C.D.*), describes and figures a very similar shell under the name *Spirolina longissima*. Whether this be in reality a Spiroline isomorph of the species under consideration, or a true *Articulina* with somewhat inflated segments, is very difficult to say; two of the figures harmonise with the latter rather than the former supposition.

Articulina funalis occurs at two points on the shores of Kerguelen Island—off Christmas Harbour, 120 fathoms, and Balfour Bay, 20 to 50 fathoms; off Prince Edward's Island, 50 to 150 fathoms; and in Humboldt Bay, on the north coast of Papua, 37 fathoms. In the second of these localities it is especially abundant.

Articulina funalis, var. *inornata*, nov. (Pl. XIII. figs. 3–5).

A few examples, differing from the typical *Articulina funalis* in their smooth non-striate exterior, occur in the material from Prince Edward's Island. They probably represent a mere local variety.

Vertebralina, d'Orbigny.

Lituus, Soldani [1789].
Renulites, Lamarck [1804].
Renulina, pars, Blainville [1824].
Vertebralina, d'Orbigny [1826], Bronn, Williamson, Reuss, Carpenter, Parker, Jones and Brady, Karrer.

The genus *Vertebralina* was designed by d'Orbigny to embrace those porcellanous species which are planospiral in the arrangement of their earlier chambers and rectilinear in the later ones; whilst *Articulina* was intended for a parallel group in which the shell is distinctly Milioline (Tri- or Quinqueloculine) in the primordial stage and afterwards rectilinear. In the d'Orbignian classification these genera appear in different families, the former amongst the *Hélicostègues* the latter with *Agathistègues*. Of their close relationship, however, there can be no doubt, and it has been the custom of recent years to treat the whole in one series as *Vertebralinæ*, and to dispense with *Articulina* as a generic term. But if dimorphous forms of this sort are to receive generic recognition, it appears to me more convenient to acknowledge the distinction, in so far as to accept *Vertebralina* as representing the dimorphous modification of helicoid forms like *Hauerina*, and *Articulina* as the parallel condition of *Miliolina*.

Vertebralina is best known as a recent genus; the only record of its occurrence in the fossil condition is in the *Renulites opercularia* of Lamarck, a species peculiar to the Eocene of the vicinity of Paris.

Vertebralina striata, d'Orbigny (Pl. XII. figs. 14–16).

Testæ hammoniformes (lituitatæ)" Soldani, 1789, Testaceographia vol i., part. 1, p. 76, pl. xlvii. figs. *vv–zz*.
Vertebralina striata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 283, No. 1;—Modèle, No. 81
„ „ Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 32, pl. i. fig. 1.

This species, in common with many of the others enumerated in the Tableau Méthodique, was never described in zoological terms by d'Orbigny, but his Model, No. 81, and the figures referred to in Soldani's plates are sufficient indication of what was intended by the author.

The structure of the early portion of the shell in *Vertebralina striata* is tolerably uniform, the variation in contour being chiefly dependent on the number of non-spiral chambers. The rounded, non-angular outline of the segments, the absence of border or carina, and the invariable surface-ornament of delicate parallel striæ, are the minor distinctive features of the species. Some of the larger specimens measure about $\frac{1}{25}$th inch (1·0 mm.) in length.

Vertebralina striata has a wide geographical distribution. It inhabits the shallow-water margins of the seas of warm latitudes in both hemispheres, probably not extending further north than the Mediterranean, and is most frequently met with in the coral débris and littoral sands of the tropics. Of about a dozen Challenger localities, only one has a greater depth than 40 fathoms, the finest specimens being from sands dredged at from 6 to 8 fathoms.

Vertebralina insignis, n. sp. (Pl. XII. figs. 9–11).

Test compressed, planospiral, subquadrangular, nearly symmetrical bilaterally; margin angular or partially carinate. Segments few, more or less triangular in outline, embracing—the three segments of the final convolution (with or without a single additional or non-spiral segment) forming almost the entire visible shell. Surface decked with exogenous costæ, either distinct or in some parts combined so as to form an irregular reticulated ornament. Aperture a long bordered slit, on the median line of the outer face of the terminal chamber. Length, $\frac{1}{25}$th inch (1 mm.).

This fine handsome variety is sufficiently characterised in the foregoing description. It differs from the typical *Vertebralina striata* in its stouter proportions and bilateral symmetry, the embracing segments, more or less cultrate periphery, and bolder surface-ornament.

Vertebralina insignis is exceedingly rare. The figured specimens are from the coral-reefs of Tongatabu, Friendly Islands, 18 fathoms. It also occurs off Raine Island, Torres Strait, 155 fathoms; and a single specimen has been found in dredged sand from off Culebra Island, West Indies, 390 fathoms.

Ophthalmidium, Kübler.

Oculina, Kübler and Zwingli [1866].
Ophthalmidium, Kübler [1870].
Hauerina, pars, Brady [1879].

Under the generic name *Oculina*,[1] subsequently changed by Kübler to *Ophthalmidium*,[2] because the former term was already employed by naturalists for another and very different group of organisms, Kübler and Zwingli have described a number of anomalous *Miliolæ*, obtained by them from various beds of Liassic and Oolitic age in Switzerland and elsewhere.

There can be little doubt that several of the specimens figured by these authors are simply *Spiroloculinæ* with that irregularity of contour which is a not uncommon feature of the early representatives of the genus, and they are very similar in general character to the species named by Terquem and Berthelin *Spiroloculina concentrica*, the multiform conditions of which are illustrated by a large series of drawings in their memoir on the Foraminifera of the Middle Lias of Essey-lès-Nancy.[3]

But amongst Kübler and Zwingli's specimens there are some, that for example described and figured as *Ophthalmidium liasicum*, in which there is a distinct deviation from the Spiroloculine plan of growth, the commencement of the shell being planospiral and non-septate (Cornuspiral), and these may very properly be taken as the type of an intermediate group. If we accept the dimorphous, or occasionally trimorphous condition of the test as the essential character, the minor structural features laid down by Kübler need not be insisted upon. The supposed perforation of the shell-wall which he describes as of frequent occurrence has been adverted to both by Rupert Jones and by Terquem and Berthelin, and I agree with these authors in regarding the statement as probably erroneous, and dependent on an imperfect method of observation. Many of the specimens are punctate, that is to say, studded with superficial pits or depressions, and when mounted in Canada balsam or turpentine, and examined by transmitted light, could only be distinguished with difficulty from perforated shells.

Without necessarily accepting all Kübler and Zwingli's species as belonging to the genus, I propose to adopt the term *Ophthalmidium* for the complanate *Miliolidæ* which commence growth on the Cornuspiral plan and become Spiroloculine at a subsequent stage, in some cases making a further change by putting on three or four segments in each of the latter convolutions.

The recent specimens answering to this general description may be referred to two varietal forms, in one of which the chambers are inflated and the peripheral margin

[1] Mikroskopische Bilder aus der Urwelt der Schweiz. Heft ii. der mikroskopischen Mittheilungen. Neujahrsblatt von der Bürgerbibliothek in Winterthur, 1866; p. 11, pl. i. fig. 24, &c.

[2] Die Foraminiferen des schweizerischen Jura, Winterthur, 1870, p. 46.

[3] *Mém. Soc. géol. France*, 1875, sér. 2, vol. x. mém. III., pl. xvii. figs. 1–4.

rounded, whilst in the other the chambers are more or less kept apart by thin shelly plates, and the margin is carinate.

Ophthalmidium inconstans, H. B. Brady (Pl. XII. figs. 5, 7, 8).

Hauerina inconstans, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 54.

Test complanate, thin; commencing growth as a planospiral non-septate tube encircling a somewhat inflated primordial chamber. At a later stage the spiral becomes segmented by constrictions at two opposite points in each convolution, and the chambers assume a Spiroloculine arrangement; and in large specimens the latest convolutions often consist of three or (more commonly) four arcuate or sigmoid chambers. Segments furnished with a broad peripheral wing, which serves to separate the successive convolutions to a greater or less degree. Diameter of large examples, $\frac{1}{15}$th inch (1·6 mm.).

Specimens of *Ophthalmidium inconstans* in their fullest development partake more or less of the characters of *Cornuspira*, *Spiroloculina*, and *Hauerina;* and in the absence of sufficient material to serve as the basis of a new generic group, the form was treated in a previous paper as an aberrant species of the last-named genus. A considerable number of specimens, however, have since been collected, and the identity of their general structure with some of the Mesozoic fossils, described by Kübler under the generic term *Ophthalmidium*, has been satisfactorily made out.

It is only rarely that large winged specimens, such as that represented in fig. 5, are met with, and all that have been found hitherto are a good deal broken at the edges; but small shells, with the more regular contour of figs. 7, 8, measuring about $\frac{1}{50}$th inch (0·5 mm.) in diameter, are not uncommon.

The distribution of the species appears to be world-wide. I have record of its occurrence at upwards of twenty Stations, scattered over the North and South Atlantic, the Southern Ocean, and the North and South Pacific. The depths vary from about 100 to 2300 fathoms, but they are mostly between 350 and 1000 fathoms. The number of specimens found in any single locality is never very large.

Ophthalmidium tumidulum, n. sp. (Pl. XII. fig. 6).

Test complanate, commencing growth as a rounded tube coiled upon a somewhat inflated primordial chamber in a planospiral manner; the earlier convolutions non-septate and *Cornuspira*-like, the subsequent ones constricted at intervals and eventually more or less regularly Spiroloculine; peripheral edge rounded. Aperture arched or rounded, formed of the slightly constricted end of the tube. Longer diameter, $\frac{1}{30}$th inch (0·8 mm.).

The non-carinate variety of *Ophthalmidium* is altogether rarer than the carinate form previously described, and in the few localities in which it has been found it occurs in company with the latter species. The figured specimen is from the Challenger Station No. 24, off Culebra Island, West Indies, 390 fathoms.

Hauerina, d'Orbigny.

Hauerina, d'Orbigny [1846], Jones and Parker, Reuss, Karrer, Brady, Schwager, Steinmann.

The genus *Hauerina*, reduced to its original d'Orbignian dimensions by the transfer to *Planispirina* of the species with Nummuline extensions of the chamber-walls, and to *Ophthalmidium* of the complanate forms with more distinctly Milioline characters, constitutes a compact and easily recognised group. It may be said to comprise the planospiral porcellanous Foraminifera which are Milioline only in the very early stages of growth, and have more than two segments in each of the later convolutions ; with smooth unornamented exterior, and porous aperture.

The dimorphous habit, smooth exterior, and comparatively small number of segments serve to distinguish the genus from *Peneroplis;* and the porous aperture, together with the absence of Nummuline lamination of the shell-wall, separate it from *Planispirina*. From *Spiroloculina* it is readily known by the number and arrangement of the chambers and by the aperture, notwithstanding certain intermediate forms, such as *Spiroloculina fragilissima* (Pl. IX. figs. 12–14), which are an occasional source of difficulty. It is perhaps open to question whether the Cretaceous species described by Reuss, *Hauerina antiqua*,[1] with its large dome-shaped aperture, would not under the present arrangement be better placed in the genus *Planispirina*, but this can only be determined by the re-examination of the specimens. The *Peneroplis laubei* of Karrer,[2] appears to be a true *Hauerina* with somewhat embracing chambers.

The geographical distribution of *Hauerina* is limited to the comparatively shallow waters of tropical and subtropical seas. Geologically, its earliest representative is the Cretaceous form already referred to, and less ambiguous species are found in the Miocene beds of the Vienna Basin (d'Orbigny, Karrer) and of the Banat (Karrer).

Hauerina compressa, d'Orbigny (Pl. XI. figs. 12, 13).

"Testæ hammoniformes, &c." Soldani, 1789, Testaceographia, vol. i., pt. 1, p. 76, pl. lxix. fig. 1.
Hauerina compressa, d'Orbigny, 1846, For. Foss. Vien., p. 119, pl. v. figs. 25–27.

D'Orbigny's description of *Hauerina compressa* needs but little modification to be equally applicable to recent and fossil specimens. In general terms the living examples of the species are somewhat larger and less regular in contour than those found in the

[1] *Sitzungsb. d. k. Ak. Wiss. Wien*, 1862, vol. xlvi. p. 35, pl. ii. fig 1, *a*, *b*.
[2] *Ibid.*, 1868, vol. lviii. p. 154, pl. iii. fig. 9.

Tertiary beds of the neighbourhood of Vienna, somewhat thinner also, and with scarcely so many segments in the outermost convolution. But these are variable characters, in which considerable latitude may properly be allowed. Recent specimens are occasionally as much as 1·0 mm. in diameter, and seldom have more than three chambers in the final whorl, whilst those from the Miocene are stated to be about one-third smaller, and have usually four peripheral segments.

So far as can be gathered from the Challenger material, the present distribution of *Hauerina compressa* is restricted to a very small area. It occurs in two dredgings in the narrow sea between the northernmost part of Australia and the island of New Guinea, namely, off Booby Island, 6 to 8 fathoms, and off Raine Island, 155 fathoms, and a few small and doubtful specimens have been found in an adjoining locality; but beyond these limits it has not been observed. Some years ago the species was included in a list of Foraminifera obtained from Dr. Gwyn Jeffreys' Hebrides dredgings,[1] but these specimens must now be referred to the genus *Planispirina*.

Of its geological history nothing is known beyond its occurrence at one or two points in the Miocene of the Vienna Basin.

Hauerina circinata, H. B. Brady (Pl. XI. figs. 14–16).

Hauerina circinata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 47.

Test nautiloid, thin, complanate; composed of two or three convolutions, the last of which, consisting of six or seven segments, completely encloses those previously formed, segments arched, thin and rounded at their peripheral margins; sutural lines marked by external constrictions. Colour milky white, sufficiently translucent to show the outline of the inner whorl of chambers. Aperture consisting of a number of perforations distributed irregularly over the septal face of the terminal segment. Diameter, $\frac{1}{25}$th inch (1 mm.).

Hauerina circinata is distinguished from the typical *Hauerina compressa*, not only by its more regularly nautiloid form and the larger number of chambers in each circuit, but by its embracing segments and thin diaphanous shell. The almost complete investment of each convolution by the succeeding one, and the presence at the same time of the true Hauerine aperture, mark the species as a connecting link between *Hauerina* and *Planispirina*.

In distribution *Hauerina circinata* appears to be limited to the same narrow area as the typical form. It has only been found in four shallow-water dredgings, amongst the islands lying between Australia and Papua, namely,—off Booby Island, 6 to 8 fathoms; off Wednesday Island, 8 fathoms; Flinders Passage, 7 fathoms; and Torres Strait, 3 to 11 fathoms.

[1] Report Brit. Assoc., Nottingham Meeting, 1866, Trans. Sections, p. 69.

Hauerina ornatissima, Karrer, sp. (Pl. VII. figs. 15–22).

Quinqueloculina ornatissima, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lviii. p. 151, pl. iii. fig. 2.
„ *falcifera*, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, p. 151, pl. iii. fig. 3.
„ *ornatissima*, Brady, 1876, Quart. Journ. Micr. Sci., vol. xvi., N. S., p. 406.

This singular and beautiful species is one of the fine series of *Porcellanea* discovered by Dr. Karrer in the Miocene beds of the Banat. It is a very variable form, often irregular, almost always dimorphous in the adult state, and otherwise presenting anomalous and debateable features.

In its early stage the shell is distinctly Milioline (either Triloculine or Quinqueloculine) in the form and disposition of its segments, as shown in Pl. VII. figs. 18, 19, and rare specimens retain the same mode of growth until they are of considerable size, possibly to maturity (fig. 17). But it is far more common for the later convolutions to be divided into three segments (figs. 15, 16), or, in other words, to assume the Hauerine condition. Examples are sometimes met with in which there is no definite segmentation of the outermost whorl, and the cavity remains undivided (fig. 20), showing an approach to the structure of *Cornuspira*. The Hauerine affinity of the species, however, is attested by the aperture, which in recent shells is almost invariably porous. The fossil specimens figured by Karrer are less irregular, and though the orifice is divided it still preserves to some extent the Milioline character. The complex surface-ornament, consisting of bold transverse crenulations crossed by numerous, delicate, longitudinal striæ, imparts a peculiar and striking appearance to the shell, and renders it one most beautiful of all the porcellanous Foraminifera.

Varieties like that figured by Karrer, *loc. cit.*, as *Quinqueloculina falcifera*, are occasionally found in recent gatherings, but it is impossible to separate them from the present more typical species.

Hauerina ornatissima has its home amongst the coral-sands of the tropics, and though occasionally met with at depths as great as 200 or even 400 fathoms, it is common only in shallow water. The Challenger specimens are chiefly from the shores of the islands of the Pacific, notably the Society Islands, the Fiji Islands, and some of the smaller groups off the coast of Papua; but it occurs also off Ascension Island, off Mauritius and elsewhere.

As a fossil, its only recorded locality is the Miocene of Kostej in the Banat, as indicated in the memoir already referred to.

Planispirina, Seguenza.

Biloculina, pars, d'Orbigny [1846], Brady, Reuss, Karrer, Siddall.
Planispirina, Seguenza [1879].
Nummoloculina, Steinmann [1881].
Hauerina, pars, Brady [1881].

The large thick-shelled *Miliolæ* flattened on two sides in a direction at right angles to the normal plane of compression have long been familiar to rhizopodists under d'Orbigny's name *Biloculina contraria;* and the recent researches of Seguenza and Steinmann have led to the recognition of that species as the type of a new generic group.

About the year 1868, a number of specimens of a form closely allied to *Biloculina contraria* were obtained by the late Edward Waller, from sands dredged in the Faröe Channel, during the "Lightning" Expedition. The specimens, which were tolerably abundant, differed from *Biloculina contraria* in their relatively thinner build, the frequent asymmetry of the two sides, and the tendency to assume a crosier-like rather than a lenticular shape. Some of these, kindly supplied by the Rev. A. M. Norman, from Mr. Waller's collection, are represented in Pl. CXIV. figs. 4–7. They were at first regarded as examples of a new species of *Hauerina*, and the name *Hauerina walleri* had been assigned to them in manuscript. Prof. Seguenza, however, in his recent memoir, Le Formazioni Terziarie nella Provincia di Reggio (Calabria), has described and figured fossil organisms identical with them in every important particular, under the generic appellation *Planispirina*.

Very shortly after the appearance of Seguenza's work,[1] a memoir was published by Dr. Steinmann of Strassburg, entitled Die Foraminiferengattung *Nummoloculina*, n. g., containing an elaborate exposition of the structure and affinities of the *Biloculina contraria* of d'Orbigny. The most important conclusion resulting from Steinmann's researches was, that the planospiral habit of growth, the number of segments in the later convolutions, and above all the lateral extension of the chamber-walls with the consequent Nummuline lamination of the shell, were distinctive characters of sufficient importance to serve as the basis of a new generic group.

Simultaneously with this paper appeared one by myself, in which similar forms, found in the "Porcupine" dredgings, amongst them those figured in Pl. XI. figs. 10, 11, were described as examples of a new species of *Hauerina*.

There seems on the whole some advantage in the course followed by Seguenza and Steinmann; and, notwithstanding the close relationship of such shells to *Hauerina* on the one hand, and *Biloculina* on the other, it may be convenient to accept the two species referred to as the representatives of an independent genus, under the earlier name *Planispirina*. Aberrant forms like *Biloculina irregularis*, d'Orbigny, *Biloculina*

[1] As the question of the relative priority of the terms *Planispirina* and *Nummoloculina* is involved, it may be stated that Prof. Seguenza's memoir bears on the title-page the date 1879, and that it was in the hands of the Secretary of the R. Accad. dei Lincei in February 1877. Dr. Steinmann's paper appeared in the *Neues Jahrb. für Min.*, &c., for 1881, but the separate copies were printed and distributed at the latter end of 1880. I may be allowed to add that Pl. XI. of the present Report was drawn on the stone by Mr. Hollick as long ago as 1878, and that the resemblance of the figures of this species to some of those given by Steinmann is in a certain sense accidental.

As a matter of choice the term *Nummoloculina* seems more appropriate than *Planispirina* to a genus comprising amongst others such forms as *Planispirina sigmoidea*, but the selection in such a case is governed by the ordinary rule of precedence.

ventricosa, Reuss, and *Hauerina circinata*, Brady, furnish intermediate links connecting the new group with *Biloculina* and *Hauerina;* but these need be no obstacle to a generic subdivision otherwise practically convenient.

Further research has shown that there exist a number of species, heretofore assigned to *Hauerina* and *Quinqueloculina*, which share the more important general characters of *Planispirina communis* and *Planispirina contraria*, and it has been found needful to devise a generic description in somewhat broader terms than would have sufficed for these two forms alone. To this end I propose the following amended characters :—

Planispirina, Seguenza.

Test free, spiral, compressed; discoidal, crosier-shaped, or oblong; segments numerous: in the earlier stages either helicoid and non-septate (like *Cornuspira*), or segmented, the chambers being arranged on the Milioline plan; at a later period either planospiral (followed in some instances by a few segments arranged in a right line) or Milioline: the inner margin of each successive convolution spreading more or less over the lateral surfaces of the test, and producing a laminated condition of the walls. Aperture simple, variable in form, but not cribrate or porous.

Inasmuch as the number of segments in each convolution varies at different periods of the growth of the test, it is manifest that the distinction between *Planispirina* and

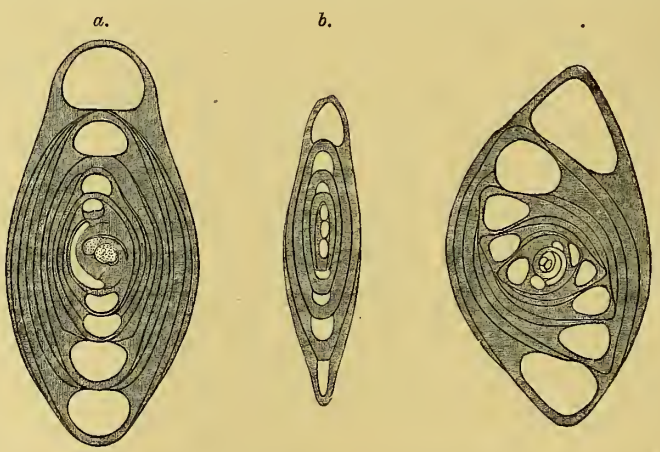

Fig. 5.—Transverse Sections of *Planispirinæ*.

Planispirina contraria, × 40 diam. *Planispirina exigua*, × 80 diam. *Planispirina sigmoidea*, × 40 diam.

Miliolina must rest chiefly on the Nummuline lamination of the shell-wall; and the same character together with the simple orifice serves also to distinguish the former from *Hauerina*.

The foregoing woodcuts illustrate this peculiar feature of the genus in its different

aspects. They represent transverse sections of *Planispirina contraria*, *Planispirina exigua*, and *Planispirina sigmoidea* respectively, accurately drawn by Mr. Hollick from specimens. Fig. *b.* is magnified to double the scale of the others, and shows that even the minute varieties have the same laminated shell as their larger congeners. In one of the lithographed figures of *Planispirina communis* (Pl. CXIV. fig. 5), the abraded surface of the specimen demonstrates, even more strikingly than a transparent section, the thickening of the shell by successive layers.

Planispirina contraria, d'Orbigny, sp. (Pl. XI. figs. 10, 11 ; Woodcut, fig. 5, *a.*).

"Nautilus" (pars), Soldani, 1780, Saggio Oritt., p. 100, pl. ii. fig. 14, *S.*
Biloculina contraria, d'Orbigny, 1846, For. Foss. Vien., p. 266, pl. xvi. figs. 4–6.
„ „ Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 466, pl. xlviii. fig. 2.
„ „ Reuss, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 70, pl. i. fig. 10.
Nummoloculina contraria, Steinmann, 1881, Neues Jahrb. für. Min., &c., N. S., vol. i. p. 34, pl. ii.
Hauerina borealis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 46.

This species, the external features of which are well known from d'Orbigny's description and drawings, may be accepted as the type of the genus. It has a stout discoidal planospiral shell, with thick rounded margin. The test is composed of six or seven convolutions, the number of segments increasing from two, in the early Milioline whorls, to five or six in the peripheral circuit; the chambers are equitant, their umbilical margins spreading in Nummuline fashion over the two lateral faces of the test (Woodcut, fig. 5, *a.*). The aperture is arched or dome-shaped, formed by the slightly constricted end of the terminal segment ; either open or partially closed by a shelly tongue projecting from the margin of the previous convolution.

Between *Planispirina contraria* and the true *Biloculinæ* every degree of modification exists, *Biloculina irregularis*, d'Orbigny (Pl. I. figs. 17, 18), being one of many intermediate varieties.

Planispirina contraria is very widely distributed, but it does not seem to be abundant in the recent condition in any one locality. On our own shores it has been dredged off Shetland, in the Faröe Channel, among the Hebrides, and off the south-west of Ireland, at depths of from 40 to 100 fathoms. It occurs at three of the Challenger Stations in the North Atlantic at 1000, 1125, and 1675 fathoms respectively, and at three in the Pacific, namely, north of Papua 1075 fathoms, off Amboyna, 1425 fathoms, and off Valparaiso (?) 2160 fathoms.

Its geological range does not appear to extend beyond the middle of the Tertiary epoch. It is found in the Miocene beds of the Vienna Basin (d'Orbigny), of Wieliczka (Reuss), and of Kostej (Karrer); and in the Pliocene of Coroncina (Soldani), and of Fossetta (Steinmann).

Planispirina communis, Seguenza (Pl. CXIV. figs. 4–7).

Planispirina communis, Seguenza, 1879, Atti. R. Accad. dei Lincei, ser. 3, vol. vi. p. 310, pl. xvii. fig. 18, 18*a*.

The drawings of *Planispirina communis* accompanying the original notice of the species are altogether insufficient to illustrate the variety of external contour which it assumes, but by the help of specimens kindly furnished by the author I have been enabled to identify a number of examples amongst the recent Foraminifera collected by the late Mr. Waller, at present in the possession of the Rev. A. M. Norman. From some of these, which had been previously set aside for independent description, the figures in Pl. CXIV. have been drawn.

The test of *Planispirina communis* is less regular than that of *Planispirina contraria;* it is seldom equally convex on the two faces, and occasionally almost flat on one side; and the peripheral margin of the spiral portion often tapers to a sharp edge. The later chambers of the adult shell generally exhibit a change from the spiral to a rectilinear mode of growth, in consequence of which the test presents a more or less elongate or crosier-like contour. This character, and the Nummuline lamination of the walls, which is well seen in abraded specimens, constitute its most conspicuous features.

The recent examples above referred to were dredged off the Faröe Islands, at a depth of 170 fathoms, and the species has not, so far as I am aware, been found elsewhere in the living condition.

The fossils which form the subject of Prof. Seguenza's description were from the deeper Pliocene deposits of Messina, in which they are stated to occur in tolerable abundance.

Planispirina exigua, H. B. Brady (Pl. XII. figs. 1–4; Woodcut, fig. 5, *b*.).

Hauerina exigua, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 53.

Test free, thin, discoidal, planospiral; composed of a number of convolutions of a narrow, slightly embracing tube. Convolutions five to eight in number; the earlier whorls non-septate, as in *Cornuspira;* those subsequently formed each divided into two or three segments; the spiral suture and septa alike obscured externally by the alar extensions of the investing wall over the lateral surfaces of the shell. Aperture a simple terminal slit. Diameter, $\frac{1}{50}$th inch (0·5 mm.) or less.

This inconspicuous little shell is common in the shallow-water sands of the tropics, and is occasionally found at greater depths amongst coral-débris. The record of its occurrence extends to nineteen localities, of which fourteen are at depths of less than 25 fathoms, the remainder ranging from 100 to 620 fathoms.

Planispirina sigmoidea, n. sp. (Pl. II. figs. 1–3 ; Woodcut, fig. 5, *c*.).

Test free, oblong, with slightly projecting or pointed ends, the two faces unequally convex, peripheral edge thin, and slightly rounded : composed of numerous segments, two to each convolution, arranged on the Milioline plan, the aperture alternately at either end of the shell. Segments seldom exceeding twelve in number, arched longitudinally, and set on at the outer margin of the alternate sides—the inner margin of the wall of each segment spreading over one lateral surface of the test, whilst the lateral extension of its successor in its turn covers the opposite side. Aperture a curved transverse orifice in the prominence at the anterior end of the shell. Length, $\frac{1}{30}$th inch (0·85 mm.).

A glance at the figures, and especially at the woodcut (fig. 5, *c*.), which represents the transverse section of the shell, will explain more accurately than any verbal description the peculiarities of structure exhibited by this somewhat anomalous form. Previous to the publication of Dr. Steinmann's paper, already referred to, the Challenger specimens had been placed amongst the *Biloculinæ*, next to *Biloculina contraria*, the accepted type of the present genus. From the last-named species *Planispirina sigmoidea* differs, *inter alia*, in two important particulars, namely, the invariably Milioline arrangement of the chambers, two in each convolution, and their oblique setting attended by the production of only a single alar flap to each segment. *Planispirina contraria*, on the other hand, as already stated, may have five or six segments in its later convolutions, and they are arranged symmetrically on one plane, whilst the alar flaps are developed equally on the two sides. The trivial name "*sigmoidea*" was suggested by the curve of the line of chambers, as seen in the transverse section of the shell.

Planispirina sigmoidea is by no means a common species, and the record of its distribution is confined to five Challenger Stations, three of which are in the North Atlantic, and two in the South Atlantic, as follows :—off Sombrero Island, West Indies, 450 fathoms ; off Culebra Island, West Indies, 390 fathoms ; off the Azores, 900 fathoms; and at two points on the coast of South America not far from Pernambuco, 675 fathoms and 360 fathoms respectively. The bathymetrical range appears from these to be from about 300 to 900 fathoms.

Planispirina celata, Costa, sp. (Pl. VIII. figs. 1–4).

Spiroloculina celata, Costa, 1855, Mem. Accad. Napoli, vol. ii. p. 126, pl. i. fig. 14 ;—1856, Atti dell' Accad. Pont., vol. vii., pl. xxvi. fig. 5.

Quinqueloculina asperula, Seguenza, 1862, Atti dell' Accad. Gioenia Sci. Nat., vol. xviii., ser. 2, p. 118, pl. ii. figs. 6, 6 *a*. *b*.

„ *asperula* and *rugosa*, Schwager, 1866, Novara-Exped., Geol. Theil, vol. ii. pp. 203, 266, pl. iv. fig. 16, *a*. *c*.

Spiroloculina celata, Brady, 1877, Geol. Mag., dec. II., vol. iv. p. 534.

This is an exceedingly interesting species, and one which, notwithstanding its abundance in many localities, seems either to have been overlooked, or what is more probable,

to have been confounded with *Miliolina agglutinans*. It was first noticed by Prof. Costa, and his figures in the Paleontologia del Regno di Napoli, though roughly executed and wanting in texture, are tolerably characteristic. In addition to the drawings of the exterior of the test, he gives an imperfect diagram of a longitudinal section, in order to demonstrate its supposed Spiroloculine affinity. There is no foundation for this view, beyond the fact that many of the thinner specimens resemble certain varieties of *Spiroloculina* in general contour, though easily distinguished by other characters.

In the common typical form of *Planispirina celata* (Pl. VIII. figs. 1, 2), the disposition of the segments is practically identical with that of *Planispirina sigmoidea*, as may be seen by the comparison of the transverse sections (Pl. II. fig. 3, and Pl. VIII. fig. 4); and though the alar prolongations of the chambers are more difficult to trace, owing to the composite nature of the test, there is sufficient evidence of the same general plan of growth. Indeed, the species appears to represent the arenaceous condition of *Planispirina sigmoidea*, just as *Miliolina agglutinans* and *Spiroloculina asperula* represent the sandy modifications of the typical forms of their respective genera.

The external characters of *Planispirina celata* are generally sufficient to distinguish it from *Miliolina agglutinans*, the only species with which it is likely to be confused. The test is oblong or oval with produced and pointed ends; the lateral surfaces are convex and the periphery thin and angular or slightly rounded. The curves of the peripheral margin at the two edges have a tendency to become sigmoid, one side being gibbous near the apex the other near the base of the shell. The end view has a very similar outline that is to say, unequally biconvex, the gibbous portion of one surface opposing the less convex portion of the other. The aperture is small and arched, and placed transversely nearly on the median line.

Planispirina celata occurs in all the great oceans; but out of a list of thirty localities, fifteen are in the North Atlantic. Compared with *Miliolina agglutinans* it is a deep-water species, and finds its most congenial home at depths of from 300 to 1500 fathoms, though its recorded range extends from 28 to 1630 fathoms.

In the fossil condition it has been found in the later Tertiaries of Italy (Costa, Seguenza) and of the Nicobar Islands (Schwager).

Sub-family 4. **Peneroplidinæ.**

Cornuspira, Schultze

(?) *Soldania*, pars, d'Orbigny [1826].
Orbis, pars, Philippi [1844].
Operculina, pars, Reuss [1845], Czjzek, Costa.
Cornuspira, Schultze [1854], Parker and Jones, Reuss, Carpenter, Seguenza, Stache, Brady, Schwager, Terquem, Karrer, Gümbel, Hantken, Norman, Tate and Blake, &c.
Spirillina, pars, Williamson [1858], Parfitt, Terquem.

The essential characters of the test in *Cornuspira* can be stated in very few words. It is discoidal or complanate in contour, and consists simply of a non-septate porcellanous tube coiled upon itself in one plane, the open or very slightly constricted end serving as the aperture. It is isomorphous with *Spirillina* in the hyaline, and with *Ammodiscus* in the arenaceous series.

The *Cornuspiræ* are connected with the true *Miliolæ* by Kübler's genus *Ophthalmidium*, which embraces a number of dimorphous varieties, spiral and non-septate in their earlier stages, and subsequently *Spiroloculine* in their mode of growth. The affinity of the genus with *Planispirina* and *Hauerina* is indicated by the little discoidal *Planispirina exigua*, the shell of which is planospiral throughout, but the early whorls are non-septate like *Cornuspira*, whilst the later convolutions are segmented as in the two former genera. Lastly, its relationship to *Orbitolites* is attested by the deep-sea *Orbitolites tenuissima*, in which not only is the initial portion of the test distinctly Cornuspiriform, but occasionally even the later whorls revert to the non-septate condition.

One or two species of *Cornuspira* attain large dimensions, but for the most part the genus is represented by specimens of relatively minute size.

The geographical range of the genus is world-wide, without much reference to latitude or depth of water. The finest known specimens, however, are from various points in the North Atlantic, at depths of from 300 to 600 fathoms.

Its geological distribution probably commences with the Liassic period, but some doubt exists as to the Mesozoic species, owing to the failure of authors to discriminate between *Cornuspira* and the isomorphous genera. From the commencement of the Tertiary epoch it is found in microzoic deposits of almost every age down to the present time.

Cornuspira foliacea, Philippi, sp. (Pl. XI. figs. 5–9).

Orbis foliaceus, Philippi, 1844, Enum. Moll. Sicil., vol. ii. p. 147, pl. xxiv. fig. 26.
Operculina striata, Czjzek, 1848, Haidinger's Nat. Abhandl., vol. ii. p. 146, pl. xiii. figs. 10, 11.
„ *plicata*, Id. Ibid., p. 146, pl. xiii. figs. 12, 13.
Cornuspira planorbis, Schultze, 1854, Organism. Polythal., p. 40, pl. ii. fig. 21;—1860, Wiegmann's Archiv, p. 287.
Operculina ammonitiformis, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 209, pl. xvii. fig. 16.
Spirillina foliacea, Williamson, 1858, Rec. For. Gt. Br., p. 91, pl. vii. figs. 199–201.
Cornuspira foliacea, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 408, pl. xv. fig. 33.

Cornuspira foliacea may be taken as the type of the genus. The test is proportionately thinner and flatter than that of most of its congeners, and the successive convolutions widen more rapidly; it is devoid of exogenous ornament, but often marked with curved transverse lines of growth. The aperture, in fully grown specimens, is a

long narrow slit, corresponding to a transverse section of the widened tube. The shell often attains comparatively large dimensions, and some specimens dredged in the Faröe Channel measure as much as $\frac{1}{3}$ inch (8·5 mm.) in diameter.

The typical *Cornuspira foliacea*, though found sparingly in almost every part of the world, is more particularly a North Atlantic species, and consequently is of much more common occurrence in the "Porcupine" dredgings than in the material brought home from the Challenger expedition. It has been met with at six Challenger Stations, of which three are in the North Atlantic; one in the South Atlantic, off Pernambuco, 350 fathoms; and two amongst the Australasian Islands, namely, off Raine Island, 155 fathoms, and off Kandavu, 210–255 fathoms. It is generally distributed over the area embraced by the three cruises of the "Porcupine" and is not uncommon on our own coast. Its bathymetrical range extends from shallow water to about 1500 fathoms, without much reference to bottom temperature, the finest specimens being found at from 300 to 600 fathoms.

The geological history of *Cornuspira foliacea* does not extend beyond the Tertiary epoch. It occurs in the Eocene "calcaire grossier" of the environs of Paris (Parker and Jones), in the Miocene of the Vienna Basin (Czjzek), in the Septaria-clays of North Germany (Reuss), in the later Tertiaries of Southern Italy (Costa, Seguenza), in the Crag of Suffolk (Searles Wood), and in the Post-tertiary deposits of Norway (Crosskey and Robertson), of the west of Scotland (Robertson), and of the north-east of Ireland (Wright).

Cornuspira involvens, Reuss (Pl. XI. figs. 1–3).

Operculina involvens, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 370 pl. xlv. fig. 20.
Cornuspira involvens, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 39, pl. i. fig. 2.
„ „ Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 3, pl. iii. figs. 52–54.

Cornuspira involvens differs from the typical *Cornuspira foliacea* in its general contour. The two surfaces of the shell are concave and the peripheral edge is thick and rounded; the convolutions become gradually stouter as they succeed each other and are somewhat embracing, instead of remaining thin and widening rapidly. The number of convolutions is very variable, but it is usually greater in the present species than in *Cornuspira foliacea*. The primordial end of the tube is sometimes swollen so as to form a sort of central chamber. It is often difficult to distinguish small specimens of *Cornuspira involvens* from minute annelids; and shells having but few convolutions or presenting irregularities of structure, as well as all adherent specimens, are on that account to be regarded with

suspicion. The diameter of the test seldom exceeds $\frac{1}{20}$th inch (1·26 mm.), and small examples are often less than one-fourth of that size.

Cornuspira involvens occurs at between twenty and thirty Challenger Stations, the list including localities in the North and South Atlantic, the Southern Ocean, and the North and South Pacific. It was found in the most northerly sounding made on the last British North-Polar Expedition (lat. 83° 19′ N.), and in the material obtained by the Austrian Expedition, off Franz-Josef Land and in Barents Sea. In point of fact it is cosmopolitan. Its ordinary bathymetric range appears to be from 7 fathoms to 700 fathoms, but in two cases the depth recorded is much greater, namely, 1325 and 1900 fathoms respectively.

The geological history of the species extends to the early portion of the Tertiary epoch. It has been found in the Septaria-clays of Offenbach and Hermsdorf in North Germany (Reuss), in the Baden Beds of the Vienna Basin (Reuss), in the Clavulina-Szabói Beds of Hungary (Hantken), in the Crag of Suffolk (Searles Wood), and in the Boulder-clay of the north-east of Ireland (Wright).

Cornuspira carinata, Costa, sp. (Pl. XI. fig. 4, *a.b.*).

Operculina carinata, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 209. pl. xvii. fig. 15, *A.B.*
Cornuspira carinata, Seguenza, 1862, Atti dell' Accad. Gioenia di Sci. Nat., vol. xviii. p. 93.
„ *bornemanni*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 39, pl. i. fig. 3, *a. b.*
„ *marginata*, M. Sars, 1868, Videnskr.-Selsk. Forhandl., p. 249.

The general characters of *Cornuspira carinata* are those of *Cornuspira involvens*, but the lateral faces of the test are somewhat less concave, and the peripheral margin is bordered by a well-defined narrow keel. The diameter is about $\frac{1}{25}$th inch (1·0 mm.). It is a somewhat rare variety, isomorphous with *Spirillina decorata* in the hyaline series. Specimens of the *Cornuspira marginata* of M. Sars, with which Prof. G. O. Sars has been good enough to supply me, have the same characters as Costa's species.

Cornuspira carinata has been found at two Challenger Stations, namely:— off Culebra Island, West Indies, 390 fathoms; and off Raine Island, Torres Strait 155 fathoms, but only one or two examples in either case. The figured specimen is from one of the "Porcupine" dredgings in the North Atlantic, 1630 fathoms. The species is less rare on the coast of Norway, and has been obtained from the Lofoten Islands (Sars), and from the Hardanger Fiord (Norman); it has also been found in the Bay of Naples (Seguenza), and at depths of 70 to 120 fathoms in the Mediterranean (Robertson).

Its earliest appearance, geologically speaking, is in the Septaria-clays of North Germany (Reuss); and its occurrence at several localities in the later Tertiary deposits of Italy and the adjacent islands is recorded by Costa and Seguenza.

Cornuspira striolata, H. B. Brady (Pl. CXIII. figs. 18, 19).

Cornuspira striolata, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 713.

Test thin, flat, auriculate ; consisting of few convolutions, the last of which widens and spreads out very rapidly ; aperture an elongated slit stretching the entire length of the terminal face of the tube. Surface marked with curved transverse lines of growth, and covered with an exogenous ornament of fine, raised, closely set riblets, parallel to the axis of growth, not straight and continuous, but taking a waved and irregular course. Diameter of two specimens, $1\frac{1}{10}$th inch (31· mm.) and $\frac{2}{20}$th inch (12· mm.) respectively.

The remarkable examples of this species obtained on the cruise of the "Knight Errant" are amongst the largest known porcellanous Foraminifera, and probably *Orbitolites laciniata* and *Orbitolites tenuissima* are the only other *Miliolidæ* that approach the superficial dimensions of the larger of the two specimens. The larger shell is very thin and the walls delicate ; the smaller of the two, from which the figures in Plate CXIII. have been drawn, is thicker, and the walls are comparatively stout ; in both, the widening of the tube takes place in much the same way as the opening out of the spire in the auriculate varieties of *Peneroplis*.

The habitat of *Cornuspira striolata* is the "cold area" of the Faröe Channel, depth 540 fathoms.

Cornuspira crassisepta, H. B. Brady (Pl. CXIII. fig. 20).

Cornuspira crassisepta, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 714.

Test discoidal, biconcave, peripheral edge nearly square ; convolutions very numerous, and very narrow near the centre ; spiral septal wall thick, and marked externally by a raised limbate line. Diameter, $\frac{1}{50}$th inch (0·5 mm.) or rather more.

This is the isomorph in the porcellanous series of a somewhat rare perforate form, *Spirillina limbata*. It is a little shell with well-marked characters, and not likely to be confounded with any other species except perhaps the next in order, *Cornuspira lacunosa*, which is about the same size, but has a rounded edge and branching superficial costæ.

Cornuspira crassisepta is one of the interesting additions to the genus obtained on the "Knight Errant" Expedition. It was dredged in the "warm area" of the Faröe Channel, at a depth of 530 fathoms, and has not hitherto been met with elsewhere.

Cornuspira lacunosa, n. sp. (Pl. CXIII. fig. 21).

Test discoidal, biconcave, peripheral edge rounded ; convolutions numerous, narrow near the centre ; aperture dome-shaped ; surface decorated, especially on the outer whorls, with a series of irregular anastomosing costæ, the main lines of which are more or less parallel to the axis of growth. Diameter, $\frac{1}{50}$th inch (0·5 mm.) or rather more.

This is a pretty variety, resembling *Cornuspira involvens* in its concave shape and rounded peripheral edge, but characterised by the somewhat peculiar reticulated surface-ornament above described. It has only been found in one locality, Station 185, off Raine Island, Torres Strait, 155 fathoms.

Peneroplis, Montfort.

Nautilus, pars, Linné [1767], Forskål, Spengler, Gmelin, Batsch, Fichtel and Moll.
Spirolina, Lamarck [1804], Blainville, Defrance, d'Orbigny, Michelotti, Costa, Karrer, &c.
Spirolinites, pars, Lamarck [1804], Blainville, Defrance.
Peneroplis, Montfort [1808], Blainville, d'Orbigny, Roemer, Reuss, Carpenter, Williamson, Parker and Jones, Karrer, Moebius, &c.
Cristellaria, pars, Lamarck [1816].
Spirula, Blainville [1825].
Dendritina, d'Orbigny [1826], Reuss, Parker and Jones, Karrer, &c.
Coscinospira, Ehrenberg [1839].

The genus *Peneroplis* comprehends a large and multiform series of porcellanous Foraminifera, characterised by polythalamous shells, the segments of which are arranged to a greater or less extent in a planospiral manner, the cavities of the individual chambers being entire, that is to say, not subdivided into chamberlets by shelly partitions. These, however, are the only features common to the whole group. The shells may be lenticular in contour, complanate, or crosier-shaped; the surface, though usually striate, may be smooth; and the aperture may be porous, or irregular and dendritic. The minor characters on which such conditions depend, though they have been made the basis of generic and specific definitions, are too variable to be of any distinctive value.

The shell is imperforate, and its texture even and homogeneous; but both the inner and outer surfaces are often marked with minute pits (Pl. XIII. fig. 23), which bear some external resemblance to the tubulation of the shell-wall in the hyaline Foraminifera, but which are easily shown to be mere superficial depressions.

As all the known recent forms of *Peneroplis* are referrible to a single zoological species, the further description of their morphological characters may be deferred. Of certain modifications of the type, which exist only in the fossil condition, I am not in a position to speak. In M. Munier-Chalmas' collection there are specimens, of early Tertiary age, which appear to be specifically or perhaps sub-generically distinct, so far as such terms can be properly used with reference to closely allied Foraminifera; but as these have not yet been described, they are outside the scope of the present notice.

An elaborate account of the genus *Peneroplis* has been given by Dr. Carpenter in the Philosophical Transactions for 1859, and again in the Introduction to the Study of the Foraminifera (p. 84), and in both memoirs the structural details are illustrated by Mr. George West's excellent drawings.

Peneroplis pertusus, Forskål, sp. (Pl. XIII. figs. 12–25).

a. Broad, complanate specimens, Pl. XIII. fig. 15.

Type—**Peneroplis planatus**, Fichtel and Moll, sp.

Nautilus (*Lituus*) *arietinus* (pars), Batsch, 1791, Conch. Seesandes, p. 4, pl. vi. fig. 15, *a.b.*
„ *planatus*, var. *β*, Fichtel and Moll, 1803, Test. Micr., p. 91, pl. xvi. fig. 1, *d.e.f.*
Peneroplis lanatus, Montfort, 1808, Conchyl. Syst., vol. i. p. 258, 65e genre.
Cristellaria planata, Lamarck, 1816, Tableau Encycl. et Méth., pl. cccclxvii. fig. 1, *a.b.c.*
„ *dilatata*, Id. Ibid. fig. 2, *a.b.c.*
„ *squammula*, Id. 1822, Anim. s. Vert., vol. vii. p. 607, No. 1.
Peneroplis planatus, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 285, No. 1 ;—Modèle, No. 16.
„ „ Williamson, 1858, Rec. For. Gt. Br., p. 45, pl. iii. figs. 84, 85.
„ *prisca*, Reuss, 1864, Denkschr. d. k. Akad. Wiss. Wien, vol. xxiii. p. 9, pl. i. fig. 7.

b. Medium, nautiloid forms with porous or dendritic aperture, Pl. XIII. figs. 16, 17.

Type—**Peneroplis pertusus**, Forskål, sp.

Nautilus pertusus, Forskål, 1775, Descr. Anim., p. 125, No. 65.
„ *planatus*, var. *a*, Fichtel and Moll, 1803, Test. Micr., p. 91, pl. xvi. *a.b.c.*
Spirolina (*Spirolinites*) *depressa*, Lamarck, 1804, Ann. du Mus., vol. v. p. 245, No. 1.
Dendritina arbuscula, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 285, pl. xv. figs. 6, 7 ;—Modèle, No. 21.
Peneroplis elegans, Id. 1839, Foram. Cuba, p. 79, pl. vii. figs. 1, 2.
Dendritina antillarum, Id. Ibid. p. 77, pl. vii. figs. 3–6.
Peneroplis proteus (pars) Id. Ibid. p. 78, pl. vii. fig. 11.
„ *pulchellus*, Id. 1839, Foram. Amér Mérid., p. 32, pl. iii. figs. 5, 6.
Dendritina hauerii, Id. 1846, For. Foss. Vien., p. 134, pl. vii. figs. 1, 2.
„ *juleana*, Id. Ibid. p. 134, pl. vii. figs. 3, 4.
„ *elegans*, Id. Ibid. p. 135, pl. vii. figs. 5, 6.
Peneroplis planatus (young), Williamson, 1858, Rec. For. Gt. Br., p. 45, pl. iii. fig. 83.
„ *pertusus*, Jones, Parker, and Brady, 1865, Foram. Crag, p. 19.
Dendritina arbuscula, Id. Ibid. p. 17, pl. iii. figs. 48, 49.
Peneroplis pertusus, Moebius, 1880, Foram. von Mauritius, p. 78, pl. iii. figs. 9–12.

c. Narrow compressed specimens, Pl. XIII. figs. 18, 19, 22.

Type—**Peneroplis arietinus**, Batsch, sp.

"Cornu hammonis," &c., Plancus, 1760, Conch. min. not., p. 120, pl. i. fig. x.
Nautilus umbilicatus, Linné, 1767, Syst. Nat., 12 ed., p. 1163, 278.
„ *semilituus*, Id. Ibid. p. 1163, 280.
„ (*Lituus*) *arietinus* (pars), Batsch, 1791, Conch. Seesandes, p. 4, pl. vi. fig. 15, *c.*
Peneroplis planatus, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 285, No. 1 ;—Modèle, No. 48.
„ *proteus* (pars), Id. 1839, Foram. Cuba, p. 78, pl. vii. figs. 9, 10.
„ *arietinus*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol xvi. p. 26, pl. i. fig 18.

d. Stout crosier-shaped specimens, circular in section, Pl. XIII. figs. 20, 21.

Type—**Peneroplis cylindraceus**, Lamarck, sp.

Nautilus (*Lituus*) *arietinus* (pars), Batsch, 1791, Conch. des Seesandes, p. 4, pl. vi. fig. 15, *d.e.f.*
Spirolina (*Spirolinites*) *cylindracea*, Lamarck, 1804, Ann. du Muséum, vol. v. p. 245, No. 2.
Spirula cylindracea, Blainville, 1824, Dict. Sci. Nat., vol. xxxii. p. 190,—Malacol., p. 382, pl. v. fig. 1.
Spirolina cylindracea, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 286, No. 1 ;—Modèle, No. 24.
„ (*Spirolinites*) *cylindracea*, Defrance, 1827, Dict. Sci. Nat., vol. l. p. 298, pl. xiii. fig. 1.
„ *clavata*, Crouch, 1827, Illust. Introd. Lam. Conch., p. 40, pl. xx. fig. 8.
Coscinospira hemprichii, Ehrenberg, 1839, Abhandl. d. k. Akad. Wiss. Berlin for 1838, pl. ii. fig. 2, *a.b.*, &c.
Spirolina austriaca, d'Orbigny, 1846, For. Foss. Vien., p. 137, pl. vii. figs. 7–9.
„ *hemprichii*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xv. p. 230.
„ *lituus*, Id. Ibid. vol. xvi. p. 35, pl. i. fig. 19.

e. Long, delicate, crosier-shaped specimens, Pl. XIII figs. 24, 25 (?)

Type—**Peneroplis lituus**, Gmelin, sp.

Nautilus lituus, Linné and Gmelin, 1788, Syst. Nat., 13 ed., p. 3372, No. 13.
„ (*Lituus*) *acicularis*, Batsch, 1791, Conch. des Seesandes, p. 4, pl. vi. fig. 16, *a.b.*
Spirolina longissima, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 225, pl. xx. fig. 11.
Peneroplis laubei, Karrer, 1868, Sitz. d. k. Akad. Wiss. Wien, vol. lviii. p. 154, pl. iii. fig. 8.

f. Stout nautiloid form, often with limbate sutures and without surface striation, Pl. XIII. fig. 14.

Type—**Peneroplis carinatus**, d'Orbigny.

Peneroplis carinatus, d'Orbigny, 1839, Foram. Amér. Mérid., p. 33, pl. iii. figs. 7, 8.
„ *dubius*, Id. 1839, Foram. Cuba, p. 79, pl. vi. figs. 21, 22.

g. Broad complanate variety, thin-shelled and without superficial striæ, Pl. XIII. figs. 12, 13.

Type—**Peneroplis lævigatus**, Karrer.

Peneroplis planatus, var. *lævigata*, Karrer, 1868, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lviii. p. 153, pl. iii. fig. 7.

Some of the earlier authors appear to have appreciated more fully than many who have written in later times the wide variation of form that must be embraced within the specific limits of *Peneroplis pertusus*. Batsch, amongst the earliest, recognised that between the broad ear-shaped shells and those of stout crosier-like contour, the whole interval was filled by gradational forms, so closely following each other that no line could be drawn that could be supposed to indicate a zoological division. There are other generic series of Foraminifera, concerning which the same sort of observation might be

made, and correctly in a certain sense; but in such cases the subordinate groups, though indistinct in outline, and often overlapping at their edges, have independent characters more or less marked, coincident with certain conditions of locality, latitude, depth, or geological age, none of which can be adduced with reference to the *Peneroplides*. Nor is there any genus of Foraminifera, embracing so great a range of external form, in which the morphological sequence is at once so simple and complete, so free from complications arising from divergent series, or from minor distinctions depending on questions of surface-ornament and the like. In stating these facts I am doing little more than repeating conclusions expressed at various times, by my colleagues Dr. Carpenter, and Messrs. Parker and Rupert Jones. Wherever *Peneroplides* abound, this wide variation exists, and nothing can be more easy than to pick out a number of striking specimens and give to each a distinctive name, but in no other way can they be divided into "species." The foregoing remarks refer primarily to the well-known living representatives of the type. There are, nevertheless, certain rare Tertiary forms, some of them attaining large dimensions and probably subgenerically distinct, concerning which little can be said at the present moment. The species referred to have been specially studied by M. Munier-Chalmas, to whose kindness I am indebted for specimens, but the results of his investigations respecting them have not yet been made public.

In the foregoing summary I have attempted nothing more than to collect references to the various modifications described by previous authors under specific names, and to arrange them round a few of the more easily recognised forms. The groups so constituted, each represented by a sort of type, are, zoologically speaking, of something less than subvarietal value, but they possess a certain amount of convenience, and at any rate the arrangement gives a succinct view of the morphological range of the genus.

The typical *Peneroplis pertusus* (*b.*) is represented by a compressed planospiral shell of about three convolutions, the width of the chambers increasing somewhat rapidly. The convolutions are sometimes investing and nautiloid, sometimes evolute and more or less visible to the centre. The degree and comparative rapidity of the widening of the spire vary with every specimen, and find their extreme development in the thin outspread shell of *Peneroplis planatus* (*a.*).

On the other hand, there are a number of modifications dependent on the change from a spiral to a rectilinear plan of growth, and the consequent production of a more or less crosier-shaped test. The intermediate condition, in which the shell is still compressed and the rectilinear portion increases very gradually in width, is exemplified in one of Batsch's figures, and may be accepted with the name *Peneroplis arietinus* (*c.*), as the type of the third series.

But the more distinctly crosier-like varieties (*Peneroplis cylindraceus, d.*) lose the compressed contour and the tendency to widening of the chambers; and, after the spiral commencement, put on a straight line of segments of nearly uniform size, and oval

or round in transverse section; whilst the most aberrant condition of all occurs in the delicate linear shells of *Peneroplis lituus* (*e.*), in which the spiral portion is relatively very small, and the remainder consists of a long string of ovoid, Nodosariform segments.

The whole of the foregoing modifications are characterised by differences in the conformation of the test, that is to say, by the shape of the segments and their mode of combination; but there are others in which the condition of the surface of the shell has been made the ground of specific distinction. It has been already stated that the genus is for the most part characterised by the striate condition of the exterior. The striæ or plicæ are usually regular and parallel, and traverse the surface of the chambers in a transverse or an oblique direction. There are, however, occasional specimens which are devoid of ornament, and present a perfectly smooth exterior. These are either of the nautiloid sort, thick-shelled, and often with slightly limbate sutures, like *Peneroplis carinatus* (*d.*), or of the broad complanate form with the shell of extreme tenuity, as in *Peneroplis lævigatus* (*g.*).

The aperture of the test in *Peneroplis* in its normal condition takes the form of a number of circular pores, which are either arranged more or less regularly in a single or double row, or scattered without order over the face of the terminal chamber. In certain cases the shell presents a single irregular dendritic orifice, apparently the result of the coalescence of a number of pores. This form of orifice has been magnified into a character of generic importance, but it has been shown by Carpenter (*loc. cit.*) that amongst the recent varieties of the genus, distinctions depending solely on trifling differences in the nature of the aperture are of no real zoological value.

The geographical distribution of the genus is very wide, and appears to be governed only by latitude and depth of water. It supplies some of the commonest Foraminifera of the shallow-water margins of tropical and subtropical seas, as far north as the Mediterranean. I am unable to concur in Dr. Carpenter's statement that the Dendritine varieties are confined to tropical latitudes, and that the Spiroline forms replace the others in deep water ("Introd.," p. 92). D'Orbigny gives "the Mediterranean near Toulon" as a locality for *Dendritina*, and the most beautiful specimens in my own cabinet, though they are not of large size, are from the opposite coast of Tripoli; and the so-called *Spirolinæ* have been found with allied forms at every depth from 8 to 250 fathoms. To judge by the Challenger collections the smooth non-striate varieties (*f.* and *g.*) appear to affect the greatest depths. They occur at Stations 24 and 33 (off Culebra Island and off Bermuda) in 390 and 435 fathoms respectively; but as shells of precisely similar character have been met with near the Cape de Verde Islands, in the Gulf of Suez, and elsewhere, at from 10 to 15 fathoms, it is manifest that they afford no evidence of any general rule. The deepest Challenger dredging in which living shells of the ordinary striate forms have been found is from Station 174 A., off Kandavu, Fiji, 255 fathoms, and the

material furnishes almost every variety, from the longest to the widest. The fact however remains, these exceptional cases notwithstanding, that the home of *Peneroplis* is at depths of less than 30 fathoms.

The geological range of the species is limited to the Tertiary epoch. It is to be met with from time to time in shallow-water deposits from the Eocene of the neighbourhood of Paris to the Crag of our eastern counties, or probably to an even later geological period.

Orbiculina, Lamarck.

Nautilus, pars, Fichtel and Moll [1803].
Archaias, *Helenis*, *Ilotus*, Montfort [1808].
Orbiculina, Lamarck [1816], Deslongchamps, Defrance, Blainville, d'Orbigny, Bronn, Williamson, Carpenter, Parker and Jones, Morris and Quekett, Reuss, Carter, Pourtales.

The genus *Orbiculina* is typified by a planospiral, porcellanous shell, the early convolutions of which are more or less equitant or embracing, and the constituent chambers narrow and regularly subdivided into chamberlets.

The typical nautiloid condition is liable to modification in two directions. Sometimes the successive segments do not increase very rapidly in size, and, instead of continuing the original spiral arrangement, are superimposed in a straight or curved linear series, so as to form a crosier-shaped test (Pl. XIV. fig. 4). On the other hand, the successive chambers may increase so rapidly in length and curvature that after a time they completely encircle the shell, which subsequently assumes a discoidal form and an annular mode of growth (figs. 8, 9).

The texture of the shell is homogeneous and imperforate, its general appearance white and polished. The surface of the test, both external and internal, is either quite smooth, or more frequently marked by minute pits or depressions (Pl. XIV. fig. 13), which at first sight may easily be mistaken for perforations. The true nature of these markings was long ago pointed out by Carpenter (Phil. Trans., 1856, p. 551), who dispelled the idea that they arose from anything more than minute superficial punctations, as had been previously supposed.

Orbiculina in all its modifications differs from *Peneroplis* in having subdivided chambers. The discoidal forms are distinguished from *Orbitolites*, which they otherwise resemble, by the convexity of the umbilical region of the shell, resulting from the investing character of the early convolutions.

The varieties of *Orbiculina* are all referrible to a single species, the details of the geographical and geological distribution of which are given in a subsequent paragraph.

The history of the genus has already been written with a completeness that leaves little room for additions, and the reader may be referred to the memoirs published by

Prof. W. C. Williamson[1] and Dr. Carpenter[2] for the details of its structure and morphology.

Orbiculina adunca, Fichtel and Moll, sp. (Pl. XIV. figs. 1–13).

Nautilus orbiculus, Fichtel and Moll, 1803, Test. Micr., p. 112, pl. xxi.
„ *angulatus*, Id. Ibid. p. 113, pl. xxii.
„ *aduncus*, Id. Ibid. p. 115, pl. xxiii.
Archaias spirans, Montfort, 1808, Conch. Systém., vol. i. p. 190, 48e genre.
Helenis spatosus, Id. Ibid. p. 194, 49e genre.
Ilotus rotalitatus, Id. Ibid. p. 198, 50e genre.
Orbiculina adunca, Lamarck, 1816, Tabl. Encycl. et Méth., pl. cccclxviii. fig. 2, *a. b. c.*
„ *nummata*, Id. Ibid. pl. cccclxviii. fig. 1, *a.–d.*
„ *numismalis*, Id. 1822, Anim. s. Vert., vol. vii. p. 609, No. 1.
„ *angulata*, Id. Ibid. p. 609, No. 2.
„ *uncinata*, Id. Ibid. p. 609, No. 3.
„ *numismalis*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 305, pl. xvii. figs. 8–10;—Modèle, No. 20.
„ *adunca*, Id. 1839, Foram. Cuba, p. 81, pl. viii. figs. 8–14.
„ *compressa*, Id. Ibid. p. 73, pl. viii. figs. 4–7.

Fichtel and Moll, with less than their usual discrimination, figure specimens of this species under three different names; whilst d'Orbigny, not generally given to the simplification of nomenclature, recognises the true relationship of the different forms, and groups together the *Nautilus angulatus*, *orbiculus*, and *adunca* of the authors referred to, as the "very young," "young," and "adult" condition of the same species. He stops short, however, at the spiral varieties, and fails to perceive how slight is the modification involved in the addition of a few annular chambers to the already nearly discoidal shell, and distinguishes the circular or nearly circular specimens by a separate name, *Orbiculina compressa*.

The fact is, that wherever *Orbiculinæ* abound the whole range of contours figured in Pl. XIV. may almost always be met with—the embracing or involute spiral, the explanate or evolute, the crosier-shaped, the fan-like, and the discoidal, together with an infinite number of gradational stages. From end to end they present an unbroken series and make but a single species. The various modifications bear no relation to locality, latitude, or depth of water, and it is quite impossible to make them up into groups of any zoological value, or with the slightest basis for subvarietal distinction.

Orbiculina adunca is an essentially tropical species, and though frequenting comparatively shallow water, or even littoral sands, it flourishes also at considerable depths. At four of the Challenger localities the depth ranges from 350 to 450 fathoms. It is common about the Cape de Verde Islands, the Bermudas, and amongst the

[1] *Trans. Micr. Soc. Lond.*, ser. 1, vol. iii. p. 105.
[2] *Phil. Trans.*, 1856, pp. 547–552; and Introd. Foram., pp. 93–99.

West Indies generally; off the coast of South America (Station 122); in the Red Sea and Indian Ocean, amongst the East Indian Islands and the Philippines. Some uncertainty exists as to its occurrence in the Mediterranean, and further evidence on this point is still wanting.

In the fossil condition its range extends as far back as the Miocene epoch, and possibly to the Eocene, but there is no record of its appearance in præ-Tertiary times.

Orbitolites, Lamarck.

Helicites, pars, Guettard [1770].
Orbitolites, Lamarck [1801], Bronn, Goldfuss, Defrance, Blainville, Serres, Michelin, d'Orbigny, Carpenter, Archiac and Haime, Parker and Jones, Carter, Norman, Brady, Moebius, Abich, &c.
Discolithus, pars, Fortis [1802].
Discolites, Montfort [1808].
Orbulites, pars, Lamarck [1816], Schweigger, Lamouroux, Deslongchamps, Defrance, Blainville.
Marginopora, Quoy and Gaimard [1833], Blainville.
Orbitulites, Bronn [1838], Reuss, Karrer, Gümbel, Terquem, Hantken
Sorites, *Amphisorus*, Ehrenberg [1839].
Cupulites, pars, d'Orbigny [1847].
Orbiculina, pars, Williamson [1851], Jones, Parker, and Brady.
Omphalocyclus, Bronn [1853].
Pavonina, Costa [1856].

The structural and morphological features of the genus *Orbitolites* have been repeatedly and exhaustively expounded by Dr. Carpenter,[1] whose latest researches, embodied in his recent Challenger Report, leave nothing fresh to be said on the more important aspects of the subject. At the same time the genus is one of peculiar interest, as representing the highest and most complex development attained by the porcellanous group of Foraminifera, and it lies within the scope of the present Memoir to direct attention to the internal structure of the shelly skeleton of the various species, so far at any rate as may be requisite to understand the meaning of the external characters by

[1] *Vide*—1850. On the Microscopic Structure of Nummulina, Orbitolites, and Orbitoides, *Quart. Journ. Geol. Soc.*, vol. vi. p. 21, pls. iii–viii.
1856. Researches on the Foraminifera,—Monograph of the Genus Orbitolites, *Phil. Trans.*, p. 187, pls. iv.–ix.
1862. Introduction to the Study of the Foraminifera, p. 105, pl. ix.
1883. Report on the specimens of the Genus Orbitolites collected by H.M.S. Challenger during the years 1873–1876, Zool. Chall. Exp., part xxi. pp. 1–49, pls. i.–viii.
1883. Researches on the Foraminifera: Supplemental Memoir; on an Abyssal Type of the Genus Orbitolites, a Study in the Theory of Descent, *Phil. Trans.*
Nor should an early paper by Prof. W. C. Williamson be overlooked :—
1851. On the Minute Structure of the Calcareous shells of some recent species of Foraminifera, *Trans. Micr. Soc. Lond.*, vol. iii. p. 105, pls. xvii., xviii.,
in which the descriptions, though brief and provisional, were far in advance of any previously published.

which they are distinguished. In the comparatively brief descriptions which follow, I have made free use of the material ready to my hands in Dr. Carpenter's Report—indeed it would have been difficult to avoid doing so; and I must refer the reader interested in the subject, either as a histological study or in its philosophical bearings, to the fuller elucidation he will find in the pages of that work.

The genus *Orbitolites* is characterised by a test of discoidal form, and generally of comparatively large dimensions, composed of chamberlets arranged either principally or entirely in concentric rings, and with an aperture consisting of marginal pores. It exhibits a certain amount of variety in the contour and disposition of the earlier chambers, which in some species are arranged in a flat spire, and in others assume the annular form from the commencement; but under no circumstances do the spiral segments constitute more than a very small proportion of the test, and they are always evolute and non-embracing. In this respect the genus differs from *Orbiculina*, which, though it sometimes puts on a small number of cyclical chambers, is essentially a spiral type, the earlier segments being always so far nautiloid and embracing as to cause a well-marked thickening of the central portion of the shell.

The terms made use of by Dr. Carpenter in his account of the structural features of the genus have been for the most part adopted in the following pages, and the subjoined woodcut with the accompanying explanation, also borrowed from his Report, will serve to illustrate their application. The figure, however, is primarily intended to demonstrate the nature of the successive modifications which lead from the simpler to the more complex types of structure, and which furnish the basis of distinction between the species.

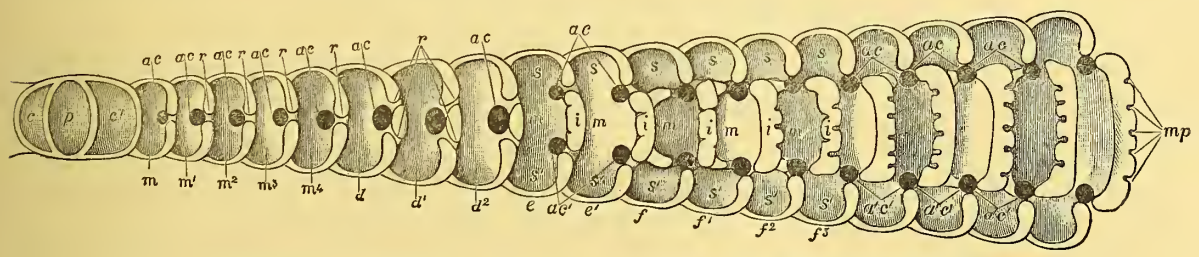

FIG. 6.—Diagrammatic representation of the progressive development of the Simple type of *Orbitolites* into the most Complex (after Carpenter).

p, primordial chamber; *c*, *c'*, circumambient chamber; *m*, m^1, m^2, m^3, m^4, chambers of successive zones of *Orbitolites marginalis*, each having its single annular canal, *ac*, and its radial stolon-passage, *r*; *d*, d^1, d^2, chambers of successive zones of *Orbitolites duplex*, each having its single annular canal *ac*, and its double radial stolon-passage *r*; *e*, *e'*, chambers of intermediate (fossil) form of *Orbitolites complanata*, each having a pair of annular canals *ac*, *a'c'*, with an interposed septum *i*, *i*, and having its superficial portions, *s*, *s*,' still in continuity with the median columns *m*, *m*; *f*, f^1, f^2, f^3, chambers of the typical form of *Orbitolites complanata*, each having its double annular canal, its median columnar portion *m*, separated from that of the next annulus by the interposed septum *i*, traversed by oblique pores, which appear as marginal pores, *mp*, at the edge of the disk; but the superficial chamberlets, *s*, *s*, and *s*, *s'*, alternating in position with the median, and each of them communicating with the annular canals of two zones, as shown at *ac*, *a'c'*

The geographical distribution of the genus extends over a very wide area. The typical *Orbitolites complanata*, in company with the more closely related forms, has its

home in the comparatively shallow waters of tropical and sub-tropical latitudes, notably amongst the coral-reefs of the North and South Pacific, and the Indian Ocean, whilst its near allies *Orbitolites duplex* and *Orbitolites marginalis* are found as far north as the Red Sea and the Mediterranean. The same varieties occur, though not in the same abundance, in similar localities in the North and South Atlantic; but in the western hemisphere, and especially in the West Indies, the genus appears to be more or less replaced by the allied type *Orbiculina*. *Orbitolites tenuissima*, on the other hand, is essentially a deep-sea Foraminifer, the field of which enlarges the geographical boundaries of the genus so as to include a considerable portion of the North Atlantic between the latitude of the entrance to the Mediterranean and Baffin's Bay.

The geological range of *Orbitolites* extends back as far as the Lias formation of the Eastern Alps; but it is not until the latter part of the Cretaceous period that it becomes an important or prevailing type. It is abundant in certain deposits of Eocene age, and its occurrence has been noted at almost every succeeding stage of the Tertiary epoch.

Orbitolites tenuissima, Carpenter [*italica*, Costa, sp.?], (Pl. XV. figs. 6, *a–d*, 7).

Pavonina italica, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 178, pl. xvi. figs. 26–28.
Orbitolites tenuissimus, Carpenter, 1869, Proc. Roy. Soc., vol. xviii. p. 421;—1870, Ibid., vol. xix. p. 155.
„ „ Wyville Thomson, 1873, Depths of the Sea, p. 91, woodcut, fig. 10.
„ „ Norman, 1876, Proc. Roy. Soc., vol. xxv. p. 211.
„ *tenuissima*, Carpenter, 1883, Report on the Genus Orbitolites, p. 16, pls. i. ii.

Orbitolites tenuissima stands apart from the rest of the genus, not only in the structural characters of the test, but in the local conditions of latitude and depth of water under which it is found.

The shell is distinguished by its extreme tenuity and by the comparative simplicity of the arrangement of the parts. Its form is that of a circular or nearly circular disk, the surfaces of which are flat or slightly concave. When fully grown, it measures $\frac{6}{10}$ths inch (15 mm.), or more, in diameter, whilst the thickness seldom exceeds $\frac{1}{300}$th inch (0·084 mm.), and is frequently much less. Externally the sutural lines are marked by slight grooves or depressions, and the walls are so thin that not only the septa but the radial partitions by which the chambers are subdivided can be seen either by reflected or transmitted light. In point of structure the test is trimorphous, forming at the commencement a non-segmented convoluted tube, to which is added a series of chambers arranged on a spiral plan; and these in their turn are succeeded by a similar series, of which each chamber forms a complete annulus. This repeated change in the mode of growth constitutes one of the distinctive characters of the species, and as the steps by

which it is brought about are of considerable importance in their morphological bearings it is necessary they should be clearly understood.

In the earliest stage the test consists of a flattened, planospiral tube, which, after a number of very narrow convolutions, widens somewhat rapidly, exactly after the manner of *Cornuspira foliacea*. In some specimens this central portion is tubular from the very beginning, as shown in fig. 6, *a*, and fig. 7 ; but in others the tube has its origin in a small circular primordial chamber, as seen in one of Dr. Carpenter's drawings (Report on Orbitolites, pl. i. fig. 1). The later convolutions of the Cornuspiral portion are sometimes constricted, either at irregular intervals or at opposite points of the periphery, thus interposing something like a Spiroloculine stage before the formation of the subdivided chambers. The broad end of the Cornuspiral shell serves as the commencement of a series of arched chambers, which follow on in the same spiral direction. These segments increase rapidly in length and curvature, and become successively more and more embracing until, by the meeting of the lateral ends, they completely encircle the shell. After this point is reached, the remainder of the test is made up by the addition of annular segments, each applied to the peripheral margin of its predecessor.

The spiral and annular chambers, which collectively constitute almost the entire shell, are subdivided by radial partitions into a multitude of minute chamberlets. These partitions or secondary septa project from the inner wall of the chamber, and do not quite reach its outer margin, but leave a continuous peripheral passage by which the connection between the chamberlets of each annulus is maintained. The chamberlets are long and narrow, the longer diameter being in the radial direction.

The peripheral wall of each chamber is perforated at regular intervals, and each pore opens into a chamberlet of the succeeding annulus. The marginal pores of the final chamber form the aperture of the test.

The foregoing description embodies the typical characters of the species. Examples of deviation from the normal structure are neither numerous nor very important, and they are generally confined to slight modifications of existing features. Occasionally, between the Cornuspiral commencement and the subdivided chambers one or two undivided segments are interposed, which represent a sort of Peneropline stage of development; and in rare instances some of the later annuli revert to the undivided condition, as shown in fig. 6, *d*.

So far as at present known, the geographical distribution of *Orbitolites tenuissima* is confined to the North Atlantic and the Mediterranean. It occurs at one Challenger Station, near the coast of North America, off Cape Hatteras, depth 1700 fathoms; and at seven or eight " Porcupine " Stations to the west and north-west of Ireland, at depths of 630 to 1443 fathoms. On the cruise of the " Valorous " it was taken at two points considerably further north (about lat. 56° N.), depth 690 fathoms and 1450 fathoms respectively; and at one point in Baffin's Bay, lat. 62° 6′ N., depth 1350 fathoms, which latter

appears to represent its northernmost limit. As remarked by Dr. Carpenter, these localities are all characterised by a low bottom-temperature, 37° Fahr. (2°·8 C.), or less. The remaining localities are,—Setubal Bay, coast of Portugal, 64 fathoms; the Mediterranean, near Carthagena; and the Ægean, 250 fathoms. The Rev. A. M. Norman states that he has "received specimens from the Marquis da Monterosato, dredged in 100–200 fathoms off the Sicilian coast[1]"; and, further, that during the dredging operations of "le Travailleur" in the Bay of Biscay, specimens which "equalled a sixpence in size" were obtained at a depth of 1200 fathoms, in the deep ravine known as the Fosse de Cape Breton.[2]

Orbitolites tenuissima has not heretoforc been recognised as a fossil species; nevertheless Costa (Palcontologia del regno di Napoli, part 2, pl. xvi. figs. 26–28) has figured two specimens which seem to place beyond question its existence in the later Tertiaries of Southern Italy. The drawings referred to are named *Pavonina italica*, and it is impossible to compare them with thosc in Pl. XV. of the present Report, especially fig. 7, or with the central portion of one of the figures given by Dr. Carpenter (Report on Orbitolites, pl. i. fig. 1), without the conviction that they are taken from specimens with almost precisely identical characters, although the former, like many of Costa's illustrations, are somcwhat lacking in detail. The fossil shells are obviously only fragments, a circumstance sufficiently accounted for by the extreme tenuity of the test.[3]

Orbitolites marginalis, Lamarck, sp. (Pl. XV. figs. 1–5).

Orbulites marginalis, Lamarck, 1816, Hist. Nat. Anim. s. Vert., vol. ii. p. 196, No. 1.
Sorites orbiculus, Ehrenberg, 1839, Abhandl. d. k. Akad. Wiss. Berlin (for 1838), p. 134, pl. iii. fig. 2, *a*, *b*, *c*.
Orbiculina (*Orbitolites*) *complanata*, Williamson, 1851, Trans. Micr. Soc. Lond., ser. 1, vol. iii. p. 115, pl. xvii. fig. 8; pl. xviii. figs. 9, 10.
Orbitolites marginalis, Carpenter, 1856, Phil. Trans., p. 192, pl. ix. figs. 1–4, &c.
„ *complanata*, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. vi. p. 29, No. 32.
„ *marginalis*, Carpenter, 1883, Report on the Genus Orbitolites, Zool. Chall. Exp., part xxi. p. 20, pl. iii. figs. 1–7; pl. iv. figs. 1–5.

Orbitolites marginalis resembles the allied *Orbitolites tenuissima* in the comparative simplicity of its structure, the chamberlets being arranged as in that species in a single

[1] *Proc. Roy. Soc.*, 1876, vol. xxv. p. 211.

[2] *Report Brit. Assoc.*, 1880, Swansea Meeting, p. 389.

[3] Costa appends the following remark to his description of the species,—"La sua fragilità è somma, onde rarissimi sono gli esemplari che abbiam potuto raccorre meglio conservati, niuno essendovene senza qualche mancanza più o meno sensibile." *Op cit.*, p. 180.

The author states that specimens are not uncommon in the Tertiary marls of Reggio; it is therefore probable that the species will be found again in the same or similar deposits. Should the view which I have taken prove correct, the specific name "*italica*" will of course take precedence of "*tenuissima*." Costa himself appears to have been in great doubt about the Foraminiferal nature of the organism, and suggests that it may even belong to the vegetable kingdom.

tier. The adult shell seldom measures more than $\frac{1}{5}$th inch (5 mm.) in diameter, with a thickness of about $\frac{1}{170}$th inch (0·15 mm.), and frequently does not attain more than half these dimensions.

The centre of the test is occupied by a "nucleus," consisting of a rounded primordial cell opening into a second or circumambient chamber, and this is followed by a number of arched segments arranged spirally in one plane. The spiral segments increase progressively in length and in degree of curvature, until by the meeting of the two ends the normal cyclical plan of growth is established, after which the remainder of the test is constructed of concentric zones. Except just at the commencement, the whole of the segments are subdivided into chamberlets by radial partitions. The septal walls and secondary septa are much thicker than those of *Orbitolites tenuissima*, and the chamberlets, as seen on the surfaces of the test, are nearly round in outline.

The connection between the chamberlets of the same chamber is maintained by lateral stoloniferous tubes or galleries just within the peripheral wall. The communication between the successive annuli is established by means of radial passages proceeding from the lateral galleries, and not from the chamberlets themselves, except when additional chamberlets are interposed to provide for the increasing length of the segments. The more or less regular alternation of the chamberlets of the successive zones is due to this arrangement. The radial passages of the final chamber form the aperture of the test, and appear externally as a line of equidistant pores on the peripheral face.

The simple structure of the test, its spiral commencement, and the rounded form of the chamberlets, are sufficient, taken collectively, to distinguish *Orbitolites marginalis* from any of its allies; and the species is more likely to be confounded with the complanate varieties of *Orbiculina* (Pl. XIV. fig. 9) than with the forms generically related to it. In *Orbiculina*, however, the early chambers are not only spiral but nautiloid or embracing, and the test in consequence exhibits a well-marked thickening of the umbilical region, which is never observed in *Orbitolites*.

In its geographical distribution, *Orbitolites marginalis* is closely associated with the complex type *Orbitolites complanata*, the home of both being the shallow-water sands of tropical and sub-tropical seas; but it is not so abundant as the latter species, nor quite so widely diffused. It has been noticed at thirteen Challenger Stations, of which eleven are in the neighbourhood of the islands of the Pacific, the depths ranging from six fathoms to 620 fathoms; the remaining two are,—off Culebra Island, West Indies, 390 fathoms, and off Bermuda, 435 fathoms. It has been found also in shallow dredgings from the Mediterranean and from the Red Sea, and in shore-sands from Madagascar.

There is no satisfactory record of its occurrence in the fossil condition.

Orbitolites duplex, Carpenter [*macropora,* Ehrenberg, sp.?] (Pl. XVI. fig. 7).

Orbulites macropora (?), Lamarck, 1816, Hist. Nat. Anim. s. Vert., vol. ii. p. 197, No. 5 (*fide* Carpenter).

Orbitolites macropora (?), Goldfuss, 1826, Petrefacta Germaniæ, &c., vol. i. p. 41, pl. xii. fig. 8, *a. b.*

Amphisorus hemprichii, Ehrenberg, 1839, Abhandl. d. k. Akad. Wiss. Berlin (for 1838), p. 134, pl. iii. fig. 3.

"*Orbitolites,* duplex type," Carpenter, 1856, Phil. Trans., p. 120, pl. v. fig. 10; pl. ix. fig. 10.

Orbitolites complanata, var. *macropora,* Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 289;—vol. vi. p. 38, No. 35.

„ *duplex,* Carpenter, 1883, Report on the Genus Orbitolites, Zool. Chall. Exp., part xxi. p. 25, pl. iii. figs. 8–14; pl. iv. figs. 6–10; pl. v. figs. 1–13.

The forms distinguished by Dr. Carpenter, in his recent Challenger Report, under the name *Orbitolites duplex,* though referred to in his earlier accounts of the genus, had not previously been separated in a specific sense from *Orbitolites complanata.* They nevertheless appear to exemplify well differentiated and tolerably constant structural peculiarities, equally removed from those of *Orbitolites marginalis* on the one hand, and *Orbitolites complanata* on the other. They represent in fact an intermediate stage somewhat more complex than the former, but not attaining the full development of the latter type.

The shell of *Orbitolites duplex,* like those of its congeners, takes the form of a circular disk, with flat or very slightly concave surfaces. The diameter never exceeds about $\frac{1}{3}$rd inch (8·4 mm.) and the maximum thickness, at or near the margin, about $\frac{1}{80}$th inch (0·3 mm.). The central portion or nucleus presents intermediate characters. It consists of a primordial chamber surrounded by a circumambient chamber, and this is followed by two or three incomplete circlets, after which the cyclical mode of growth commences immediately without the interposition of any distinct series of spiral segments. Both the septal walls and the secondary septa are thicker, in proportion to the size of the cavities they enclose, than those of *Orbitolites marginalis,* and the concentric annuli are in consequence less distinctly marked on the exterior. On the lateral faces of the test the chamberlets appear in the shape of circular spots, each bounded by its own wall; and those of the adjacent annuli alternate more or less regularly with each other. The peripheral face is marked by a double row of pores, which serve collectively as the aperture of the test. The pores of the two rows are generally but not invariably placed alternately.

The double row of external orifices marks the chief distinctive feature of the test, and indicates the point in which the internal structure differs from that of the simple type. The disk of *Orbitolites marginalis,* as already stated, consists of a single tier of chamberlets, each circlet of which has its own annular gallery into which all the constituent chamberlets open freely, and from which a single series of radial passages are given off connecting it with the succeeding annulus. The test of *Orbitolites duplex,* on the other hand, is

composed of a double tier of chamberlets, one above, the other below, and the free intercommunication of the sub-segments of each annular chamber is still maintained by a single annular gallery; but there are two series of radial passages (instead of one) given off from it, which lead respectively to the upper and lower tier of chamberlets of the succeeding annulus. The double row of marginal pores, already alluded to as visible on the outermost segment, are the openings of these radial passages. This arrangement of the parts will be readily understood by reference to the annexed diagram of the transverse section of the shell. (Woodcut, fig. 7, *b*.)

The principal external features by which *Orbitolites duplex* may be distinguished from *Orbitolites marginalis* are the annular form and concentric arrangement of the segments from the commencement, and the double row of peripheral orifices; whilst the latter character, together with the rounded outline of the chamberlets as seen on the two faces of the disk, affords a ready means of separation from *Orbitolites complanata*. In the complex type, as will presently be explained, the chamberlets, especially those of the later annuli, are more or less elongated in the radial direction, and the marginal pores are multiplied indefinitely.

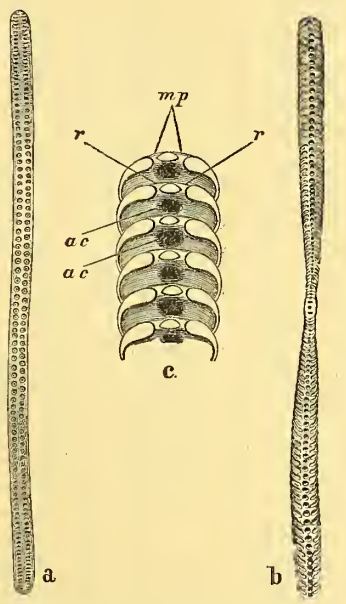

Fig. 7.—*Orbitolites duplex*, Carpenter.
a. Peripheral aspect, showing the double row of marginal pores; magnified 12 diam.
b. Transverse section; magnified 12 diam.
c. Portion of the same; magnified 50 diam.
m.p. Marginal pores.
r.r. Radial stolon passages.
ac, *ac*, Annular canals.

It is almost impossible with our present knowledge to lay down the area of the geographical distribution of *Orbitolites duplex*, as distinct from that of the allied forms with which it has hitherto been specifically associated, and equally difficult to ascertain accurately the limits of its occurrence in the fossil condition. To do either would necessitate the re-examination of specimens from all the various localities at which the genus is known to exist. The species is found most plentifully in the shallow water of tropical seas. It is a prominent form in the Red Sea, where it was originally discovered by Ehrenberg, and it occurs in the Mediterranean, at least as far north as the coast of Sardinia. Well-marked specimens have also been obtained from shore-pools in the Cape de Verde Islands.

If, as Dr. Carpenter supposes, the *Orbulites macropora* of Lamarck (*Orbitolites macropora*, Goldfuss), is referrible to the same species, it is probable that its geological range in Tertiary times is analogous to that of *Orbitolites complanata*.

Orbitolites complanata, Lamarck (Pl. XVI. figs. 1–6;—irregular and monstrous specimens, Pl. XVII. figs. 1–6).

"Retepora *Muscipula* minima," Soldani, 1795, Testaceographia, vol. i., part 3, p. 242, pl. clxvii. figs. *ss*, *tt*; pl. clxviii. fig. *xx*.
Orbitolites complanata, Lamarck, 1801, Syst. Anim. s. Vert., p, 376.
Discolites concentricus, Montfort, 1808, Conch. Systém., vol. i. p. 187, genre 47e.
Orbulites complanata, Lamarck, 1816, Nat. Hist. Anim. s. Vert., vol. ii. p. 196, No. 2.
Marginopora vertebralis, Quoy and Gaimard, 1833, Voyage de l'Astrolabe; *fide* Blainville, 1834, Man. d'Actinologie, p. 412, pl. lxix. figs. 6, 6 *a–c*.
Orbitolites complanata, d'Orbigny, 1850, Prodr. de Palćont., vol. ii. p. 405, No. 1295.
„ „ Carpenter, 1850, Quart. Journ. Geol. Soc., vol. vi. p. 30, pl. vii. figs. 24-30;—1856, Phil. Trans., p. 224, pls. iv.–ix., &c.
Orbiculina (*Orbitolites*), sp. ined., Williamson, 1851, Trans. Micr. Soc. Lond., ser. 1, vol. iii. p. 117, pl. xviii. figs. 11–14.
Orbitolites complanata, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 291, No. 2.
Orbiculina compressa, Joncs, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 21, pl. iii fig. 43.
Orbitolites orbiculus, Id. Ibid. p. 23, pl. iii. figs. 45–47.
Orbitulites præcursor (?), Gümbel, 1872, Neues Jahrb. für Min., &c., p. 256, pl. vii. figs. 1–10.
Orbitolites complanata, Carpenter, 1883, Report on the Genus Orbitolites, Zool. Chall. Exp., part xxi. p. 29, pl. v. figs. 14–18; pls. vi., vii., viii.

This species exemplifies the highest development of the Orbitoline type, not only in point of size, but still more in complexity of structure.

The test is a circular disk, the surfaces of which are as a rule distinctly concave; but very large specimens are sometimes nearly flat, the depression being confined to a small area in the centre, and not unfrequently, in such cases, the disk becomes somewhat thinner again near the margin. The peripheral edge is thick and slightly convex or rounded. Ordinary well-grown specimens vary in diameter from $\frac{1}{25}$th inch to nearly 1 inch (1 mm. to 25 mm.), and in thickness from $\frac{1}{80}$th inch to $\frac{1}{10}$th inch (0·3 mm. to 2·5 mm.).

The central portion or "nucleus," consisting of the primordial and the circumambient chamber, is relatively larger than in the other species of the same genus; and the first annular band of chamberlets is formed directly upon it without the interposition of partial or incomplète circlets; so that except the "nucleus" the entire shell is made up of concentric zones of chamberlets. The number of zones varies greatly according to the size of the specimen, and is stated by Dr. Carpenter to range from 3 to 160 or more. The aperture of the test consists of a large number of marginal pores, which show a disposition to an arrangement in transverse lines of greater or less regularity.

Each of the concentric zones of which the shell is composed consists of three parts, namely, two superficial layers, separated by a thicker mass, which for the purposes of description has been termed the "intermediate stratum." The superficial layer of each zone is composed of a single tier of chamberlets, somewhat elongated in the radial direc-

tion. The superficial chamberlets of the same zone have no immediate connection with each other, nor is there any direct connection between the superficial chamberlets of the adjacent annuli. The communication is maintained indirectly by means of the annular galleries, in a manner analogous to that which has been observed in the simpler types, each chamberlet having two pores or passages, one at each end, opening respectively into the annular canals of its own zone and the previous zone. And, as there are two superficial layers of chamberlets in the complex type, so there are two series of annular canals.

The "intermediate stratum" is composed of columnar or cylindrical chamberlets, which, making some allowance for irregularities, correspond in number and arrangement with those of the superficial layers. These columnar sub-segments terminate above and below in the annular gallery of the zone to which they belong, and they each communicate by stoloniferous passages with the contiguous chamberlets of the preceding and succeeding annuli. The radial stoloniferous passages of the cylindrical segments of the outermost zone form the marginal pores which are seen on the exterior. From what has been stated it will be seen that the complete intercommunication of the various parts of the cavitary system is attained, firstly, by the opening of the chamberlets both of the superficial layers and of the intermediate stratum into the annular canals; and secondly, by the direct stoloniferous passages between the chamberlets of the concentric zones of the intermediate stratum.

In the very young condition the shell is occasionally adherent, growing attached to the fronds of algæ or other similar bodies, as shown in Pl. XVI. figs. 2, 3; but more frequently it is free from the commencement, and specimens in the very earliest stage, consisting of nothing more than the "nucleus" (fig. 1), are often found amongst the sand of localities in which the species abounds.

The shells of this species are subject to irregularities of growth which take place in many different ways. Perhaps the commonest sort of monstrosity is that illustrated by some of the figures in Pl. XVII., in which a portion of a second disk is projected from one of the lateral faces of the test (fig. 1). Occasionally portions of more than one supplementary or out-growing disk are found, as in figs. 3, 4, and 5; and other forms of irregularity, dependent on uneven or arrested growth, are not unfrequent.

Orbitolites complanata has probably a wider geographical distribution than any of its congeners. It is found in the shallow margins of tropical and sub-tropical seas, but it is more generally diffused over the eastern than the western hemisphere. It is common on the shores of the Pacific, from the Loo-choo Islands and the Sandwich Islands on the north, to the coast of Tasmania on the south, attaining its best development on the coral-reefs of the Fiji and the Friendly Islands, and it is almost equally abundant in the Indian Ocean. There appears to be some doubt as to its presence in the Red Sea and the Mediterranean, at any rate its reported occurrence requires confirmation. It has been

observed off Ascension Island, 7 fathoms; off the coast of South America, near Pernambuco, 350 fathoms; off Cape de Verde Islands, 11 fathoms; off Sombrero Island, 450 fathoms, and elsewhere in the West Indies; and in coral-sands from Bermuda.

Owing to the confusion in which the nomenclature is involved, it is difficult to state precisely the geological range of this species. Gümbel has described and figured, under the name *Orbitulites præcursor*, an Orbitolite of the complex type, obtained from the Alpine Lias of the neighbourhood of Roveredo, which appears to differ in no important particular from the living representatives of the present form, except in its small and somewhat obscure spiral commencement. Setting this aside, probably the earliest known appearance of the species is in the Upper Cretaceous formation of Maestricht and elsewhere in the Low Countries (Faujas, Hagenow, Bronn). It occurs in the Early Tertiaries of the Gironde (d'Orbigny); in the "Calcaire grossier" of the vicinity of Paris (Lamarck, d'Orbigny, Goldfuss, &c.), and in that of Forêts and St. Gilles in Belgium (Galeotti); in the "Calcaire moellon" of Montpellier (Serres); in the Bracklesham Beds of Hampshire, (Fisher); and in the yellow Nummulitic Limestone of North-Western India (Archiac). Lastly, it has been found in the Miocene of Malta (Brady), and in the Crag of the east of England (Jones, Parker, and Brady).

Orbitolites complanata, var. *laciniata*, H. B. Brady (Pl. XVI. figs. 8–11).

"*Orbitolites* with plicate margin," Carpenter, 1856, Phil. Trans., pl. v. figs. 2, 3.
"*Orbitolites*, complicirte Varietät," Bütschli, 1880, Bronn's Kl. u. Ord. d. Thier-Reichs, vol. i. pl. v. fig. 4.
Orbitolites laciniatus, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 47.
Orbitolites complanata, var. *laciniata*, Carpenter, 1883, Report on the Genus Orbitolites, Zool. Chall. Exp., part xxi., pl. vii.

This is an exceedingly interesting modification of *Orbitolites complanata*. The central portions of the test show but little deviation from the normal plan of growth; but near the margin, the disk becomes strongly sinuate or crumpled, and usually at the same time splits horizontally so as to form a double periphery, the two edges of which approximate at intervals, but otherwise are separated by deep irregular fissures. Under favourable conditions the specimens attain very large dimensions, and are not unfrequently an inch (25 mm.) or more in diameter. The division of the margin entails no departure from the typical structure, as each lamella presents the same arrangement of the parts as the disk itself; but in some of the outer annuli the partitioning into chamberlets is often incomplete or altogether wanting (Pl. XVI. fig. 11).

The salient peculiarities of the test are no doubt the result of exuberant growth, and consequently assume a great diversity of form; but although no two specimens are exactly alike in the shape or extent of the marginal development, the same general

character is always apparent. Shells belonging to the "laciniate" group are readily distinguished from the class of specimens already referred to, in which the anomalous features depend on mere irregularity of growth or on actual additions to the test (Pl. XVII. figs. 1–5), and which for the most part partake more of the nature of monstrosities than of definable varieties.

The occurrence of *Orbitolites complanata*, var. *laciniata*, is limited to a few localities. It was obtained in great abundance in shallow water on the coral-reefs of Tongatabu, Friendly Islands, and of the neighbouring Fiji group, but was not collected elsewhere during the Challenger voyage.

Sub-family 5. Alveolininæ.

Alveolina, d'Orbigny.

Discolithus, pars, Fortis [1801].
Nautilus, pars, Fichtel and Moll [1803].
Borelis, Montfort [1808], Bronn, Ehrenberg.
Miliolites, *Clausulus*, Montfort [1808].
Fasciolites, Parkinson [1811], Sowerby.
Melonites, Lamarck [1812].
Alveolites, Defrance ? [1816], Brongniart.
Oryzaria, Defrance [1820].
Melonia, Defrance [1824], Blainville, Deshayes, Eichwald, Reuss.
Alveolina, d'Orbigny [1826], Deshayes, Reuss, Leymerie, Czjzek, Rütimeyer, Carter, Archiac and Haime, Carpenter, Gemmellaro, Parker and Jones, Karrer, Gümbel, Brady, Moebius, &c.
Orbiculina, pars, d'Orbigny [1846].

The generic term *Alveolina* is employed for a group of recent and fossil porcellanous Foraminifera, the most familiar examples of which are the long fusiform shells conspicuous amongst the microzoa of coral-sands. These represent one extreme of a somewhat extensive morphological series—that in which the axis of growth is longest as compared with the breadth of the test. The other forms are relatively shorter and broader, and take successively elliptical, prolate, spherical, oblate, and discoidal shapes, according to the degree in which the length of the axis is diminished. The minute structure of the shell of the various modifications of the genus has been so fully described and illustrated by Dr. Carpenter (Introd. Foram., p. 99 *et seq.*) that anything further than a brief account of its more interesting general features would be superfluous.

The shell is spiral, and consists of a number of arched segments wound around a more or less elongated axis, each chamber being divided into a number of smaller spaces or chamberlets. The outline of the segments is marked externally by depressed lines, nearly equidistant and extending from pole to pole ; and slighter furrows, at right angles to the principal sutures, indicate the position of the secondary septa which subdivide the chambers

In point of internal structure the genus furnishes examples of two somewhat distinct modes of growth corresponding to the simple and complex types of *Orbitolites*. In the simple type, to which the small, spheroidal, recent form and most of the fossil species pertain, the long arched chambers are divided by vertical septa into chamberlets, and the normal aperture consists of a line of bordered pores on the outer face of the terminal segment, corresponding in number to the chamberlets into which the segment is partitioned. Occasionally there is a second or accessory row of smaller pores. This simple type is easily understood by its analogy to a nautiloid *Orbiculina* drawn out at the two umbilici.

In the complex type, of which the common recent *Alveolina boscii* furnishes the best example, the chambers are not only divided by vertical septa, as before described, but the individual chamberlets are subdivided by horizontal partitions into a number of parallel layers or storeys; and, instead of a single row of orifices, the face of the terminal segment is studded with numerous pores, disposed in more or less regular lines corresponding with the subdivisions of the chamber-cavities. A comparison of the longitudinal and transverse sections (Pl. XVII. figs. 14, 15, with figs. 11, 12), or still better, a reference to Dr. Carpenter's larger and more diagrammatic drawings, will show at a glance the distinctive features of the two types of structure.

Carter has described a Tertiary form, *Alveolina meandrina*, the shell of which exhibits traces of a canal system in the early stages of growth; but he suggests at the same time that the species is probably more nearly related to *Nummulites* than to *Alveolina*.[1]

So far as at present known, the geographical distribution of the genus is limited to the shallow water of tropical seas, and in such localities it is abundant and widely diffused.

From a geological point of view, *Alveolina* is best known by its Tertiary representatives; nevertheless d'Orbigny, in the Prodrome de Paléontologie, enumerates two species from the Cenomanian or Middle Cretaceous rocks of the south of France, and one from the Turonian or Upper Cretaceous beds of the same or an adjoining region. Fossil specimens are found in some abundance in the Nummulitic Limestones of France (Pyrenees), Spain, Persia, and Northern India; in the Eocene beds of the neighbourhood of Paris and of the south of England (Bracklesham), and in the Miocene of various parts of Austria and Transylvania.

Alveolina boscii, Defrance, sp. (Pl. XVII. figs. 7–12).

Alveolites larva, (?) Defrance, 1816, Dict. Sci. Nat., vol. i. p. 137.
Oryzaria boscii, Id. 1820, Ibid. vol. xvi. p. 104.
Alveolina boscii, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 306, No. 5;—Modèle, No. 50.
„ *elongata*, Id. Ibid. p. 307, No. 6.
„ *quoii*, Id. Ibid. p. 307, No. 7.
„ *longa*, Czjzek, 1847, Haidinger's Nat. Abhandl., vol. ii. p. 143, pl. xii. figs. 34, 35.
„ *boscii*, Moebius, 1880, Foram. Mauritius, p. 79, pl. iii. figs. 13–15; pl. iv. fig. 1.

[1] *Ann. and Mag. Nat. Hist.*, 1861, ser. 3, vol. viii. p. 381, pl. xvii. fig. 4.

The *Oryzaria boscii* of Defrance, as rendered by d'Orbigny in Model No. 50, is a better representative of the common recent forms of *Alveolina* than either the ovoid *Miliolites sabulosus* of Montfort or the somewhat attenuated *Aveolina quoii* of the "Tableau Méthodique"; but between the stout form with rounded extremities and the elongate subcylindrical varieties, every gradation of contour is to be met with. Under favourable conditions recent specimens of this species attain a length of half an inch (12 or 13 mm.), and shells but little smaller than this are not uncommon. As previously stated, the internal structure of recent specimens is of the complex type, whilst fossil shells with the same external characters have for the most part undivided chamberlets.

The geographical distribution of *Alveolina boscii* is confined to seas of warm latitudes, and scarcely exceeds the limits of the tropical zone; but at certain depths within that area, whether in the Eastern or Western Hemisphere, it is one of the most plentiful and most generally diffused of the larger Foraminifera. It most affects the shallow water of coral-reefs, and becomes rare at greater depths than thirty fathoms. It nevertheless occurs in two deeper Challenger dredgings, namely, at Stations 260A, Honolulu Reefs, and 185, off Raine Island, depth 40 fathoms and 155 fathoms respectively, but in both cases the specimens are of very small size.

In the fossil state *Alveolina boscii* is found from time to time throughout the Tertiary epoch, its earliest appearance being in the Eocene of the Paris Basin and in the Bracklesham Beds of Sussex and Hampshire.

Alveolina melo, Fichtel and Moll, sp. (Pl. XVII. figs. 13–15).

Nautilus melo, Fichtel and Moll, 1803, Testac. Micr., p. 118, pl. xxiv.
Borelis melanoïdes, Montfort, 1808, Conch. Systém., vol. i. p. 171, genre xliii^{e}.
Clausulus indicator, Id. Ibid. p. 178, genre xlv^{e}.
Melonites sphærica, Lamarck, 1816, Encycl. Méth., pl. cccclxix. fig. 1, *a.–f.*
„ *sphæroidea*, Id. Ibid. pl. cccclxix. fig. 1, *g*, *h*.
Alveolina melo, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 306, No. 2.
Melonia costulata, Eichwald, 1830, Zool. Spec., vol. ii., pl. ii. fig. 1.
Alveolina pulchra, d'Orbigny, 1839, Foram. Cuba, p. 85, pl. viii. figs. 19–22.
„ *hauerii*, d'Orbigny, 1846, For. Foss. Vien., p. 148, pl. vii. figs. 17, 18.
„ *costulata*, Erchwald, 1853, Leth. Rossica, Dern. Période, p. 8, pl i. fig. 4.
Borelis melo, Ehrenberg, 1854, Mikrogeologie, pl. xxxvii. (sect. x. 10), fig. 1, *a.–f.*
Alveolina melo, Parker and Jones, 1861, Ann. and Mag. Nat. Hist., ser 3, vol. viii. p. 164.
„ „ Moebius, 1880, Foram. Mauritius, p. 79, pl. iv. figs. 2, 3.

The spheroidal or broadly elliptical forms of *Alveolina*, typified by *Alveolina melo*, are much less common in the recent state than the elongate varieties. As already described, their internal structure is simpler than that of their living congeners, and in this respect they more nearly resemble some of the fossil species, especially those abounding in the limestones of the Nummulitic period or somewhat later.

The arched chambers of which the shell is composed are individually divided by vertical secondary septa into a single row of chamberlets, each of which has a simple orifice. There is no further subdivision of the chamber-cavities by horizontal partitions, as in the fusiform and subcylindrical varieties with which the species is commonly found associated.

Recent specimens of *Alveolina melo* have been found amongst the coral-sands of the West Indies, Bermuda, Cape de Verde Islands, Ascension Island, the Gulf of Suez, Mauritius, Ceylon, and the Sandwich Islands, but in no case at greater depth than 40 fathoms. The shells, as a rule, are of much smaller dimensions than those met with in the fossil condition, and seldom exceed $\frac{1}{35}$th inch (0·75 mm.) in longer diameter. The specimen figured by Ehrenberg (*loc. cit.*) is from the Karst, near Triest, on the shores of the Adriatic, but whether recent or fossil is not stated by the author.

In determining the geological distribution, it is not easy to separate *Alveolina melo* from the allied *Alveolina ovoidea* and *Alveolina elliptica;* but its occurrence in the Nummulitic limestones of Hungary and Transylvania is attested by various authors, and its presence in the Eocene of the neighbourhood of Montolieux and Couiza (France) and the Miocene of Nussdorf near Vienna, is recorded by d'Orbigny.

Sub-family 6. Keramosphærinæ.

Keramosphæra, H. B. Brady.

Keramosphæra, Brady [1882].

Test free, spherical ; composed of a multitude of chamberlets arranged more or less regularly in concentric layers.

This genus comprises only a single species.

Keramosphæra murrayi, H. B. Brady.

Keramosphæra murrayi, Brady, 1882, Ann. and Mag. Nat. Hist., ser. 5, vol. x. p. 242, pl. xiii.

Test free, porcellanous, spherical; formed of concentric layers, each consisting of a large number of chamberlets arranged more or less regularly in single series. Chamberlets of the same layer communicating with each other by short lateral stolons ; those of the successive layers by the pores which formed the superficial apertures of the previous layer. Aperture consisting of numerous pores, one at the margin of each chamberlet. Colour white ; surface areolated by the irregular outlines of the somewhat convex chamberlets of the peripheral layer. Diameter, about $\frac{1}{10}$th inch (2·5 mm.).

Only two specimens of this interesting type have hitherto been found, and both in

the same locality. They are, or rather were, for one of them has been utilised for sections, spherical shells of $\frac{1}{10}$th and $\frac{1}{11}$th inch (2·5 and 2·3 mm.) diameter respectively, of milky-white colour and porcellanous texture; the entire surface was areolated or blistered, the areolæ being irregular in outline and each apparently corresponding to a single chamberlet. The general appearance of the larger of the two, of the natural size, and as seen under a magnifying power of 25 diameters, is given in the woodcut (fig. 8, *a.b*). A nearly central section was subsequently made of the same shell, portions of which, more highly magnified, are shown in figures *c.* and *d.*

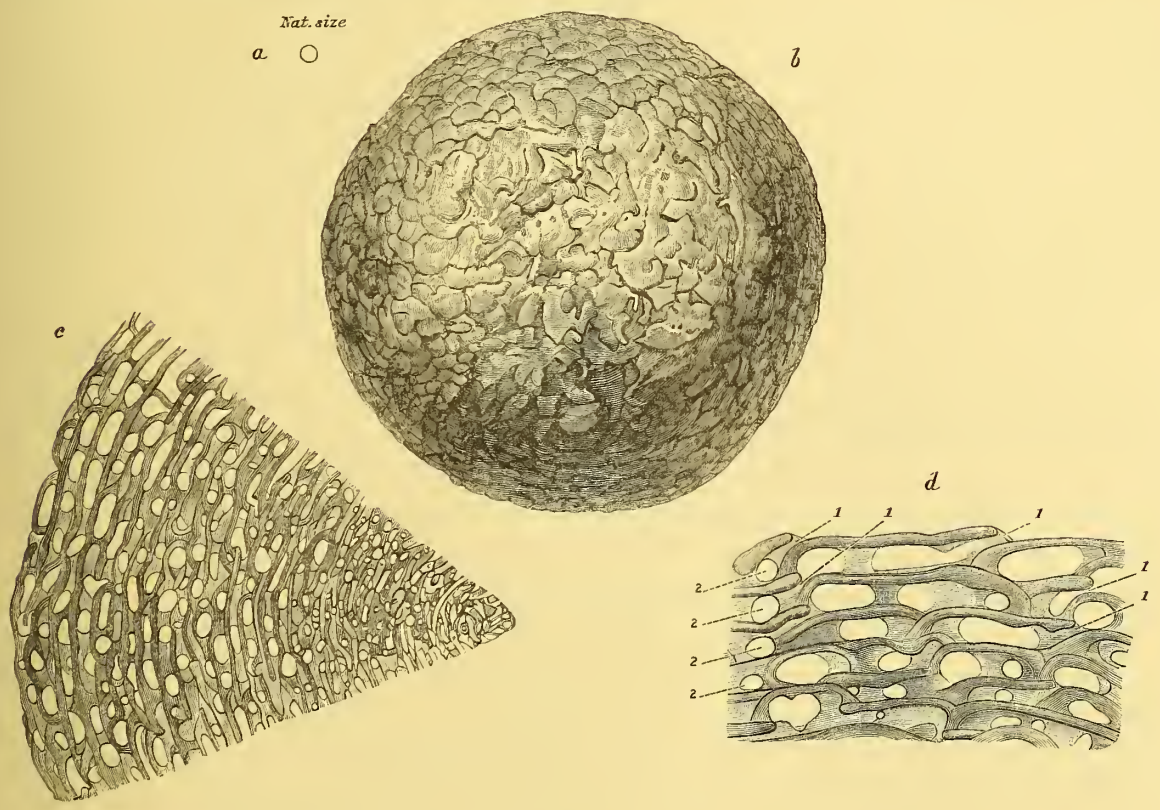

FIG. 8.—*Keramosphæra murrayi.*

Fig. *a.* *Keramosphæra murrayi*, natural size; *b*, magnified 25 diameters.
Fig. *c.* Portion of a nearly central section of the same specimen, magnified 50 diameters.
Fig. *d.* A smaller portion of the same, magnified 100 diameters, showing 1, 1, 1, 1, the orifices communicating between the chamberlets of the successive layers; 2, 2, 2, 2, lateral orifices communicating between the chamberlets of the same layer.

The general arrangement of the test is easily understood by a comparison of these drawings. They show that it is composed of chamberlets arranged in more or less regular concentric layers, that the chamberlets are convex on their outer surface, and that they vary somewhat in size and shape, but not to such an extent as to interfere with a tolerably symmetrical plan of growth.

To determine the minute structure with any degree of completeness, and especially the nature of the communication that subsists between the chamberlets, would require a number of sections made on different planes, and for these the necessary specimens are not at present forthcoming; nevertheless, with the help of allied organisms, the anatomy of which is well known, the available material is sufficient for the elucidation of all the more important and characteristic features.

A preliminary examination brings one fact into prominence, namely, the close analogy that exists between the arrangement of the chamberlets in the sectional view and that found in the genus *Orbitolites;* indeed there is scarcely any portion of the section to which a counterpart may not be found amongst the figures which accompany Dr. Carpenter's memoir on the latter type.[1] It must, of course, be borne in mind that the section of a spherical test does not, like the horizontal section of an Orbitolite, present a series of chamberlets grouped on a uniform level, the whole of which, together with their means of intercommunication, can be seen at one time, but represents rather the aspect of a plane projected through a mass of cells so arranged that they are necessarily intersected at different angles.

It may be noticed that although the section (fig. *c.*) passes through nearly the centre of the shell, it does not show any distinct primordial chamber. It is probable, therefore, that the initial chamber is of small size and perhaps scarcely distinguishable from the chamberlets, as is often the case in Orbitolites of the simple type. The early layers are comparatively thin and the constituent chamberlets small; and either for this reason or because the centre of the section happens to be thicker than the rest, the arrangement appears somewhat confused, and not without a certain resemblance to the labyrinthic structure of some of the complex *Alveolinæ.*

Referring to fig. *d.*, which represents part of the section near the periphery much more highly magnified, it will be seen that the communication between the successive layers is maintained by tubular orifices, 1, 1, 1, 1, one at the margin of each chamberlet, and that these orifices are set obliquely close to the line of union with the contiguous chamberlets. In the external layer they serve collectively as the general aperture of the test, and correspond to the marginal pores of the Orbitolite; but they are not so conspicuous on the exterior, owing to their peculiar position and oblique setting. The chamberlets of the successive layers are neither regularly alternating, as in the simple Orbitolite, nor directly superimposed; and although there is a certain degree of uniformity in their relative positions, they are too variable in size and shape to conform to any rule in this particular.

The communication between the chamberlets of the same layer is maintained by short lateral stoloniferous tubes, which are less easy to identify than those uniting the successive layers already described. They are shown, in section, in fig. *d.*, 2, 2, 2, 2. Under

[1] *Phil. Trans.*, 1856.

favourable conditions one such opening is found near each end of the chamberlet; and as a section only shows one side of the cavity, there is probably a lateral orifice communicating with each contiguous chamberlet.

The analogy of the individual layers of *Keramosphæra* to the superficial layers of a compound Orbitolite has been adduced in order to explain some otherwise obscure points in the structure of the test. It is, however, by no means complete, for in *Orbitolites* the superficial chamberlets are connected with each other by stoloniferous tubes, but have no communication with the exterior, except through the apertures on the peripheral edge of the test. In *Keramosphæra*, on the other hand, the layer of chamberlets is continuous over the entire sphere, and in the absence of an exposed peripheral edge the necessary communication with the exterior is afforded by the superficial orifices of the individual chamberlets. The only other abnormal character which requires notice is the irregularity of the outline of the chamberlets. But this anomaly is apparent rather than real, for though the complex types of porcellanous Foraminifera commonly display great symmetry and regularity in the contour and disposition of their various parts, this is by no means an invariable feature of the group. The labyrinthic subdivisions of the chamberlets in the complex *Alveolinæ* furnish a case in point; and in one porcellanous genus, *Nubecularia*, irregularity is the rule rather than the exception.

The two specimens of *Keramosphæra murrayi* were found by Mr. Murray in the siliceous diatom ooze from Station 157, a locality, roughly speaking, about twenty degrees south of the south-western corner of Australia, depth 1950 fathoms.

Family III. ASTRORHIZIDÆ.

Our acquaintance with the large arenaceous Rhizopods which constitute the family Astrorhizidæ is almost entirely derived from the operations of the various recent expeditions, organised and equipped by Government for the exploration of the deep sea. The genus *Astrorhiza* was described by Sandahl in 1857, and a closely allied type, *Dendrophrya* by Strethill Wright in 1861, but these are amongst the few forms that inhabit comparatively shallow water, and it is to deep-sea dredging in the North Atlantic during the past twelve or fourteen years that we owe the discovery of nearly all the more important members of the group.

Except in the case of a few species, of which the living animal has been to some extent studied, our knowledge of the life-history and organisation of the Astrorhizidæ is still very imperfect; and it is by the external form of the test and its minute structure, rather than by the characters of the animal inhabiting it, that the various types are recognised. Even concerning the test itself—the selection of material and the means employed for its incorporation—we are only at the threshold of research; but deficient

as our knowledge undoubtedly is, the physical characters of the investment afford the best, indeed almost the only basis at present available for the classification of the group. Our acquaintance with the distinctive characters of the genera and their limits of variation is in like manner fragmentary and insufficient; and it is more than probable that some of the forms at present accepted as independent types may be found, on the comparison of specimens obtained from fresh localities, to be nothing more than specific or varietal modifications belonging to the same generic series.

The sequence of forms resulting from the successive modifications of the conspicuous characters of the test is less easily traced in the ASTRORHIZIDÆ than in some other families of Rhizopoda, owing to the very elementary structure of many of the types.

Perhaps the simplest conceivable sort of arenaceous investment is exemplified by the genus *Psammosphæra*, which has a globular test composed of coarse sand-grains firmly cemented together. It presents no general aperture, in the ordinary sense, and has no membranous lining, but the sarcode contained in the cavity communicates with the exterior by interstitial openings at points not filled with cement. The polythalamous condition, if such it may be called, of the same typical structure, is found in the genus *Sorosphæra*, and consists of a number of such spheres of uniform size, adhering by their exterior surfaces but unconnected by any definite sarcode stolons. In the absence of true stoloniferous passages *Sorosphæra* is more like a colony of monothalamous organisms than a single polythalamous test.

Saccammina, in its simpler recent forms, presents a step in advance of *Psammosphæra*, for not only is the shell-wall more compactly built, and under ordinary circumstances imperforate, but the test has a distinct general aperture. When polythalamous, the chambers are either fusiform and united by stoloniferous tubes, or they are arranged side by side in colonies, with the orifices directed outwards.

Storthosphæra and *Pelosina*, two genera of the sub-family ASTRORHIZINÆ, present nearly parallel characters to *Psammosphæra* and *Saccammina*, but the firm, hard, arenaceous tests of the latter genera are replaced by an investment of fine sand and mud, almost devoid of cement, with smooth interior, and, in many cases, with a chitinous lining. The superficial orifices in *Storthosphæra* differ from those of its isomorph in being placed in little, irregular, pointed projections at various points of the periphery.

Amongst the PILULININÆ the genera *Pilulina* and *Technitella* are also characterised by globular or oval tests, but they are constructed of masses of sponge-spicules, felted together, the interstices being filled with loose sand in place of calcareous cement. The distinction between these two types rests only on the shape of the test and the nature of the orifice.

Thus it will be seen that in the genera *Psammosphæra* and *Storthosphæra*, *Saccammina*, *Pelosina*, *Pilulina*, and *Technitella*, the test consists typically of a spherical or oval chamber; that in the first two interstitial orifices take the place of a general aperture,

the rest having a single simple orifice; and that the distinctions between them depend primarily on the sort of material they individually select for the construction of the test, and the mode in which it is incorporated.

Turning again to the ASTRORHIZINÆ, which are characterised by their thick soft walls consisting of mud, or of only slightly cemented sand,—the longer subcylindrical varieties of *Pelosina* lead by degrees to similar forms of the genus *Astrorhiza*, which, instead of the single orifice, have an aperture at each end of the test; and these, through the compressed three-mouthed *Astrorhiza angulosa*, to the typical condition of the genus, a lenticular disk with radiating arms. The *Dendrophrya* of Strethill Wright is little more than a small irregular *Astrorhiza*, growing adherent by one of its flat surfaces; and the recently discovered *Syringammina* resembles an *Astrorhiza* with branching arms, which radiate equally in all directions, forming a subspherical instead of a flattened test.

Of the PILULININÆ, beyond the types already mentioned, *Pilulina* and *Technitella*, only one other form of test with the characteristic, felted, spicular walls is known; namely, that of the genus *Bathysiphon*, which consists of an elongated somewhat tapering tube, the open ends of which serve as the aperture.

The tubular series with firmly cemented arenaceous tests constituting the Sub-family RHABDAMMININÆ, of which *Saccammina* is but a globular modification, may be said to commence with *Jaculella*, which is represented by a tapering sandy tube, closed at the narrow end. Some specimens of this genus are scarcely distinguishable from the simpler species of *Hyperammina*, which also is typified by a nearly straight tube, but with the broad end closed and rounded. The remainder of the *Hyperamminæ* present very diverse forms; they are all tubular, either straight or sinuate, simple or branched, free or adherent, but invariably when perfect have a rounded initial chamber. The genus *Rhizammina* resembles the branched varieties of *Hyperammina*, but possesses no primordial chamber; the wall is chitino-arenaceous and flexible, and not, as a rule, solidified by much calcareous or other mineral deposit. *Sagenella*, in like manner, has a branching, tubular test, but is of parasitic habit, spreading over stones and shells, the branches often anastomosing so as to form a sort of raised network.

The genus *Rhabdammina* is connected with the foregoing by some of its irregularly branching varieties like *Rhabdammina cornuta*. The typical species *Rhabdammina abyssorum* has a radiate test consisting of three, four, or five tubular arms diverging from one point, with or without a central chamber. Straight varieties, with swollen centre, may be regarded morphologically as the two-rayed modification of the typical form, and these lead to the linear species, which consists of an arenaceous tube of nearly even diameter and indefinite length, open at both ends. *Marsipella* likewise is tubular and has terminal apertures, the test being either straight or twisted, of slender fusiform contour or of uniform diameter. Its most striking peculiarity results from its preference for sponge-spicules in the construction of the investment. They are not, however, an invariable constituent: when

present they are commonly, though not invariably, used in conjunction with siliceous sand, and are laid together side by side and strongly cemented, differing entirely in this particular from *Pilulina* and its allies.

Botellina resembles the straight *Hyperammin*æ in external contour, but the cavity of the tube is proportionately larger, and is irregularly divided by loosely-cemented, sandy dissepiments, affording support to the otherwise somewhat slender outer walls. The rounded end has interstitial orifices; and this fact has been regarded as an indication that in the normal condition the test is sessile and erect, growing attached to stones or other bodies by the narrower end.

The affinities of *Aschemonella* are not so easily traced, for in nothing is the type so remarkable as its extreme variability of contour. Except *Saccammina* it is the only genus of the *Astrorhizid*æ which betrays any tendency to distinct segmentation, though even this is not an invariable character. Compared with allied forms, the sandy investment is exceedingly thin in proportion to the bulk of the sarcode cavities, and is composed of very fine materials with an unusually hard and compact cement.

The genus *Haliphysema* stands in some respects aloof from the remainder of the group. The test is columnar and grows attached by a spuriously segmented convex base; the walls are thin and firm, and in their minute structure resemble those of *Marsipella*, being often composed to a considerable extent of sponge-spicules.

Sub-family 1. Astrorhizinæ.

Astrorhiza, Sandahl.

Astrorhiza, Sandahl [1857], M. Sars, Carpenter, Norman, G. O. Sars, Brady, Bütschli.
Haeckelina, Bessels [1874].
Astrodiscus, Schulze [1874].

Test free; depressed or fusiform. Depressed forms either sub-lenticular with angular or irregularly radiate margin, or in branching masses. Walls thick, constructed either of nearly uniform fine sand very slightly cemented, or of mud, with or without a chitinous lining. Apertures terminal; one at each end of the test in the fusiform species, and at the end of each ray or branch of the compressed forms; often more or less blocked with sand.

Little need be said of *Astrorhiza* apart from its species. The foregoing characters are sufficient for its recognition, and it is not likely to be confused with any other genus except the closely allied *Pelosina*, which, typically, consists of an undivided chamber with a single aperture. *Astrorhiza* is not known in the fossil condition.

Astrorhiza limicola, Sandahl (Pl. XIX. figs. 1–4).

Astrorhiza limicola, Sandahl, 1857, Ofvers. af Kongl. Vetenskaps-Akad. Förhandl., vol. xiv. p. 299, pl. iii. figs. 5, 6.
Astrodiscus arenaceus, Schulze, 1874, II. Jahresberichte d. Kom. Untersuch. d. deutsch. Meere, p. 113, pl. ii. fig. 10, *a.–e.*
Haeckelina gigantea, Bessels, 1874, Jenaische Zeitschr., vol. ix. p. 265, pl. xiv.
Astrorhiza limicola, Norman, 1876, Proc. Roy. Soc., vol. xxv. p. 213.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 43.

Test compressed, irregularly stellate; consisting of a central disk, with peripheral tubular arms, radiating in one plane. Arms 8 to 15 in number, irregular in form, slender; very variable in length, sometimes longer than the diameter of the disk; often divided at the end into a number of little tubular branches. Walls thick, composed of indiscriminate mud with more or less distinct chitinous lining; exterior rough, internal surface smooth. Colour greyish-brown, sometimes marked with yellowish-brown spots. Diameter of the disk about $\frac{1}{5}$th inch (5 mm.); the entire test, including the rays, often measuring $\frac{1}{2}$ inch (12 or 13 mm.) or more.

There can be no doubt as to the particular organism for which the name *Astrorhiza limicola* was intended by Dr. Sandahl; the figures of the test, as well as the terms of the description, accord accurately with the form familiar to naturalists who have dredged in shallow water on our own coast, or elsewhere in northern temperate latitudes.

The most characteristic feature of the species is the peculiar structure of the investment. It is not sandy, like that of the deep-sea varieties with which it has been frequently confounded, but the exterior is composed of mud, taken apparently without any selection from the miry bottom on which the animal lives. Within this layer of mud, which though tolerably firm is not incorporated by any inorganic cement, is a sort of chitinous envelope which lines the whole test and imparts a smooth surface to the interior. The muddy coating of the arms is thinner than that of the body of the test, and the small tubular processes into which the extremities are divided have so little extraneous covering that they shrivel and crumble away on being taken out of fluid, and are seldom seen in dried specimens.

The proportionate dimensions of the disk and the rays vary considerably. In Sandahl's drawing the disk is of about the same diameter as in the specimen represented in fig. 1, but the length of the rays is only about one-fourth the diameter of the disk. They are relatively broad, the ends are round and open, and long granular pseudopodia are shown issuing directly from them.

Dr. Bessels, who has studied living specimens obtained upon the coast of the New England States of North America, gives a drawing (*loc. cit.*) of a specimen of very similar proportions to fig. 1, but the disposition of the rays is rather more regular, and some of them have divided ends. The same author has also an interesting figure of a

number of individuals with short rays, united together in a colony. It represents seven distinct disks, intercommunicating with each other, and forming a sort of network, the arms of each serving as stoloniferous tubes connecting it with the adjacent members of the group.

But the most singular specimen which has come under my notice is one which was dredged on the coast of Haddingtonshire about ten years ago, by my friend the late F. M. Balfour. The test is less thickly beset with mud than usual, and the chitinous envelope is correspondingly more apparent; the disk is of full size, about $\frac{3}{10}$th inch (7 mm.) in diameter, and the rays are small and delicate, and branched at the ends; but proceeding from one side is a tube, of the same texture and substance as the disk, nearly an inch (25 mm.) in length, and $\frac{1}{7}$th inch (3·6 mm.) in diameter. It is possible that this may be only a monstrous individual of the species under notice. It was dredged in company with the typical form, and, except its anomalous contour, and somewhat thinner coating of mud, presents no distinctive feature. In specimens showing much irregularity it is not uncommon to find one arm a good deal larger than the rest, and the present case may perhaps represent an abnormal development of this sort.

Astrorhiza limicola has been collected at the following localities:—coast of Bohuslän, Skager-Rack, Sweden (Sandahl, Lovén); coast of Norway (Norman); off Heligoland, 21 fathoms (Schulze); off Dunbar (F. M. Balfour); west coast of Scotland, 10 to 20 fathoms (Robertson, Herdman); Northumberland and Durham, 30 fathoms (Brady); Torbay, Devon (Norman); coast of Connecticut, 25 fathoms, and Maine, U. S. A. (Bessels, Verrill).

Astrorhiza arenaria, Norman (Pl. XIX. figs. 5–10).

Astrorhiza limicola, M. Sars, 1868, Vidensk.-Selsk. Forhandl., 1868, p. 248.
„ „ Carpenter, 1868, Proc. Roy. Soc., vol. xvii. p. 173.
„ „ G. O. Sars, 1871, Vidensk.-Selsk. Forhandl., 1871, p. 252.
„ sp., Carpenter, 1876, Quart. Journ. Micr. Sci., vol. xvi. N. S., p. 221, pl. xix.
„ *arenaria*, Norman, 1876, Proc. Roy. Soc., vol. xxv. p. 213.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S. p. 43;—1882, Proc. Roy. Soc. Edin., vol. xi. p. 711.

Test free, compressed; irregular and branched, or sublenticular and more or less radiate, the terminal branches and rays being alike short and thick, and the peripheral edges rounded. Walls thick; built of uniform fine sand with but little cement; loose and granular externally. Interior cavity of the branched variety taking the form of a narrow tube, of nearly even diameter except at the points of furcation; that of the stellate variety a central chamber with radiating tubular passages; internal surface smooth. Aperture at the end of each branch or ray, usually closed with loose sand.

Length of the branching form often $\frac{1}{2}$ inch (12 or 13 mm.); diameter of radiate specimens somewhat less.

I entirely agree with the Rev. A. M. Norman in regarding the deep-water *Astrorhiza* as something quite distinct from the *Astrorhiza limicola* of Sandahl, to which species it had been assigned by Profs. M. and G. O. Sars and Dr. Carpenter; and have adopted the name which he has suggested for it in his Report on some of the Invertebrata collected during the cruise of the "Valorous" in 1875 (*loc. cit.*). In point of fact *Astrorhiza limicola* and *Astrorhiza arenaria* differ from each other as much in the minute characters of the test as in general form. In external contour *Astrorhiza arenaria* is either compressed and stellate, with the rays short and rounded, or it consists of branching cervicorn masses, and the walls are composed of uniform fine sand loosely aggregated; whilst *Astrorhiza limicola* is typically stellate, the rays assuming the form of long slender tubes often subdivided at the extremities into finer tubuli, and the walls are built of indiscriminate mud. The one inhabits the sea-bottom at depths never less than 150 fathoms or thereabouts, the other is found in shallows seldom much exceeding 20 or 30 fathoms. *Astrorhiza arenaria* has the apertures in the rounded ends of the rays or terminal branches filled with loosely packed sand, so as to be scarcely distinguishable from the ordinary surface of the test; whilst in *Astrorhiza limicola* the simple or divided extremities of the tubular arms serve the same office.

Astrorhiza arenaria occurs on the coast of Norway (M. and G. O. Sars), in Kars Fiord, 180 fathoms (Norman), and in the Faröe Channel at several points ranging in depth from 530 fathoms to 650 fathoms (Carpenter, Brady). A single fine-branched specimen is the sole representative of the species amongst the Challenger dredgings, its habitat being Station 142, off the Cape of Good Hope, 150 fathoms.

Astrorhiza crassatina, H. B. Brady (Pl. XX. figs. 1–9).

Astrorhiza crassatina, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 47.

Test elongate, subcylindrical or irregular, extremities rounded; consisting of a tube of uneven diameter, sometimes exhibiting a tendency to incipient segmentation, open at the two ends; walls thick and friable, similar in composition and texture to *Astrorhiza arenaria*. Length, $\frac{4}{10}$th inch (10 mm.).

There are many points of affinity between *Astrorhiza crassatina* and *Astrorhiza arenaria*. The general characters of the test, the material selected for its construction, and the mode in which it is employed are alike in the two species, and the frequent presence of a swollen cavity in the former, resembling central chamber of *Astrorhiza arenaria* is a further point of analogy. When there is no such chamber the tubular

cavity is often constricted near the middle, though not to the extent of actual segmentation. The apertures, which are terminal, are frequently rendered labyrinthic by partial closure with loose sand-grains.

Astrorhiza crassatina was obtained on the third cruise of the "Porcupine" in 1869, from dredgings in the Faröe Channel, at a depth of 640 fathoms. The figured specimens are nearly all from Dr. Carpenter's collection.

Astrorhiza granulosa, H. B. Brady (Pl. XX. figs. 14–23).

Marsipella granulosa, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 36, pl. iii. figs. 8, 9.
Astrorhiza granulosa, Id. 1881, Ibid. vol. xxi. p. 48.

Test fusiform, tapering nearly equally towards both ends; cavity tubular, of approximately uniform diameter. Walls thickest in the middle of the test, composed of fine grey sand; exterior loose and granular, interior nearly smooth. Apertures simple and terminal, either open or partially closed with sand-grains; often tinged brown. Length, $\frac{1}{4}$th inch (6 to 7 mm.) or more.

It is possible that *Astrorhiza granulosa* may be only a local variety of *Astrorhiza crassatina;* but the smaller and more regular test and the uniform width of the tubular cavity are sufficiently distinctive in the specimens which have come under my notice. The polystomous modification, *Astrorhiza angulosa*, also differs considerably from the corresponding species of the more northern area.

Astrorhiza granulosa has only been found at a single Challenger Station, No. 78, east of the Azores, depth 1000 fathoms; at which locality it is tolerably abundant.

Astrorhiza angulosa, H. B. Brady (Pl. XX. figs. 10–13).

Astrorhiza angulosa, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 48.

Test subtriangular (rarely quadrangular), depressed, biconvex; peripheral edge rounded: consisting of a small central chamber with radiating tubes, one of which passes to each corner, the open ends serving as apertures. Texture and substance of the walls similar to *Astrorhiza granulosa*. Diameter about $\frac{1}{6}$th inch (4 mm.).

Astrorhiza angulosa appears to be a short three-mouthed variety of *Astrorhiza granulosa*, with which species it is found associated. In these, as in some other modifications of the genus, the orifices are often blocked with loosely aggregated sand, and are not unfrequently stained reddish-brown.

The figured specimens are all from Station 78, east of the Azores, depth 1000 fathoms;

and except for a single example found in one of the "Porcupine" dredgings in the North Atlantic, 630 fathoms, this is the only locality at which the variety has been collected.

Pelosina, H. B. Brady.

Pelosina, Brady [1879], Bütschli.

Test free, typically monothalamous; rounded, cylindrical, tapering, or irregularly fusiform; walls composed of a layer of soft mud with a chitinous lining. Aperture single, terminal.

The organisms included in the genus *Pelosina* are amongst the simplest of all arenaceous Rhizopods. They take the form, for the most part, of a single undivided chamber with one terminal orifice. The test consists primarily of a chitinous envelope, which is strengthened and protected by an even and tolerably compact layer of mud. No selective power appears to be exercised with respect to the extraneous materials employed in its construction, and there is a comparative absence of any kind of cement or other incorporating medium; hence the test is soft and crumbling, especially when dried, and the requisite strength is obtained by increased thickness.

The genus has a wide distribution and an extensive bathymetrical range.

Pelosina variabilis, H. B. Brady (Pl. XXVI. figs. 7–9).

Pelosina variabilis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 30, pl. iii. figs. 1–3.

Test consisting of a single chamber, or of two or three independent chambers irregularly associated. Chambers asymmetrical, variable in shape, generally rounded, elongate, and tapering. Walls thick, composed of fine mud, deposited on a chitinous envelope which is usually extended at the oral end so as to form a membranous, tubular neck. Aperture terminal. Length of the individual chambers, sometimes $\frac{3}{4}$ inch (18 or 20 mm.), including the neck.

The typical form of the test of *Pelosina variabilis* is elongate and subcylindrical, rounded at the base and gradually narrowing towards the superior extremity, which is drawn out into a slender tube. The walls are very thick in the broader portion, but become thinner towards the narrow or apertural end, where they consist of little more than a chitinous membrane, so thin and soft that it collapses on drying. The chambers are seldom quite symmetrical, and they often assume twisted and otherwise irregular shapes. Occasionally two or three such chambers are found adhering to each other, but the attachment is superficial and there is no stoloniferous connection between them, and each

chamber apparently retains an independent existence. The cavity of the test is undivided, and the interior surface is quite smooth.

Specimens of this or a closely allied organism nearly an inch in length have been dredged on the west coast of Scotland. They have thinner tests than those figured in Plate XXVI., the walls are somewhat flexible, the shape tolerably regular, long, and tapering; and the superior extremity, which is tubular and much drawn out, is divided into a number of minute branches, each terminating in an aperture, exactly as shown in the larger arms of *Astrorhiza limicola* (Pl. XIX. fig. 1).

Pelosina variabilis only occurs at two Challenger Stations, namely, in the South Pacific, east of New Zealand, 1100 fathoms, and far north in the North Pacific, 2050 fathoms. Specimens were found in the soundings taken during the Austro-Hungarian North-Polar Expedition, off Franz-Josef Land, 125 fathoms. The large individuals described in the last paragraph were dredged by Mr. Robertson, off Cumbrae, 50 to 60 fathoms; and similar or perhaps larger examples have been collected by the Rev. A. M. Norman on the western shores of Scotland and on the coast of Norway.

Pelosina rotundata, H. B. Brady (Pl. XXV. figs. 18–20).

Pelosina rotundata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 31, pl. iii. figs. 4, 5.

Test consisting of a single, flask-shaped, or pyriform chamber with a produced membranous neck. Walls of the body thick, composed of Globigerina ooze or other soft mud. Diameter, $\frac{1}{15}$th inch (1·8 mm.).

This may perhaps be only a local variety of *Pelosina variabilis*, but it is usually of comparatively small dimensions, and consists invariably of a single globular or pyriform chamber. The walls are relatively very thick, and are composed of soft, greyish-white, muddy material, with scarcely any incorporating cement. It naturally follows that the central cavity occupies but a very small proportion of the entire bulk of the test.

Pelosina rotundata has been found at the following localities:—in the North Atlantic, south of Rockall Bank, 640 fathoms, and west of the Azores, 1675 fathoms; in the South Atlantic, south of Pernambuco, 350 fathoms; and at a single Station in the North Pacific, 2050 fathoms.

Pelosina cylindrica, n. sp. (Pl. XXVI. figs. 1–6).

Test elongate, cylindrical, straight or slightly curved; diameter nearly uniform from end to end, extremities rounded. Walls thick and soft, formed of fine mud and embedded shell fragments; interior surface quite smooth. Aperture simple, situated at the centre of one end of the test. Length, $\frac{1}{2}$ inch (12 mm.).

In general terms the test of *Pelosina cylindrica* differs from that of *Pelosina variabilis* in its nearly uniform diameter (the oral end being if anything the wider of the two) and its rounded extremities. In contour it is generally somewhat bent, and the aperture is a simple orifice, sometimes partially blocked with mud. The walls, as a rule, present the same general structure as those of the other species; the exterior is rough, and the interior surface smoothly finished.

One or two specimens have been met with consisting of two chambers of small size, joined end to end (fig. 3); but whether they represent a segmented variety, or two individuals in an early or immature stage, or simply an accidental or abnormal modification of the ordinary form, there is nothing to indicate.

If we may judge from the six Challenger Stations at which its occurrence is recorded, *Pelosina cylindrica* is exclusively a deep-water species, the distribution being as follows:—North Atlantic, off Gomera, Canary Islands, 620 fathoms, and off Sierra Leone, 1750 fathoms; Antarctic Ice-barrier, 1675 fathoms; east coast of New Zealand, 1100 fathoms; and two points far north in the North Pacific, 2900 fathoms and 2050 fathoms respectively. From the second and third of these localities the specimens differ somewhat from the normal form, the chitinous envelope being less thickly coated with mud.

Dendrophrya, Str. Wright.

Dendrophrya, Wright [1861], Bütschli, Brady.

Test adherent; consisting of a sessile chamber with erect or spreading arms. Arms tubular, irregular, often branching; with apertures at the distal ends. Walls chitinous, coated with mud.

The genus *Dendrophrya* was established by the late Dr. T. Strethill Wright for certain "Rhizopodous animals, found plentifully on Sertularias, Flustras, Fuci, and stones, in low-water pools." It is much to be regretted that the discoverer did not more clearly define the characters of the genus, and that he only figured one of the two species which he described; and still more that the type specimens were not preserved, or at any rate are not now to be found amongst his collections.

That the genus is nearly related to *Astrorhiza* is evident, both from the nature of the investment and the forms which the test assumes; and it is satisfactory to be able to state that this was Dr. Wright's own view of its affinity, as ascertained under the following circumstances. During some dredging operations on the coast of Northumberland and Durham, in the years 1862–1864, *Astrorhiza limicola* was more than once obtained. This little animal was then unknown to English naturalists, though it had been described some years before by Dr. Sandahl, and specimens were sent to Dr. Wright, thinking

that he might be able to identify the species. In his reply he confirmed the idea that had been expressed that they were large Rhizopods, and suggested that the chief difference between the specimens sent and his genus *Dendrophrya* consisted in the fact that the tests of the former were free, whilst the latter represented an essentially fixed or adherent type. To this it may be added, that Prof. Bütschli, in his recent classification of the Rhizopoda, expresses a similar opinion, and describes *Dendrophrya* as resembling morphologically an *Astrorhiza* adherent by its central disk.

For twenty years the genus appears to have remained entirely unnoticed by Rhizopodists. As the subject appeared to be one of some importance, and there were many points concerning which additional information was required, I called the attention of my friend Mr. David Robertson, F.G.S., to the original paper, thinking it possible that he might have met with the organism during his long and varied experience in shore-collecting. This did not prove to be the case, but the subject was one that interested him so much that he made a visit to the recorded locality, Old Granton Quarry, near Edinburgh, in the hope that the species might still be found there. Unfortunately on that occasion the search was unsuccessful, but ere long I received from him a number of specimens gathered from similar localities on the west coast of Scotland, amongst which it was not difficult to recognise *Dendrophrya radiata*. In company with it was an erect branching modification of the same type, which, though it does not agree in all points with the figure of *Dendrophrya erecta* in Dr. Wright's paper, has the same general characters, and there can be little doubt belongs to that species. The following notes are founded on the specimens collected by Mr. Robertson.

Dendrophrya radiata, Str. Wright (Pl. XXVII.A. figs. 10–12).

Dendrophrya radiata, Wright [1861], Ann. and Mag. Nat. Hist., ser. 3, vol. viii. p. 122.

Test sessile, depressed; consisting of a central chamber, with spreading, more or less adherent, tubular arms; arms very irregular in contour, often branching, the open distal extremities forming the pseudopodial apertures of the test. Walls chitinous, somewhat thickly coated with mud; central chamber in adult specimens firm and hard. Size very variable, rarely $\frac{1}{4}$ inch (6 mm.) in diameter.

The following is Dr. Wright's account of this species :—"Its general appearance is that of a small shelly mass, from the borders of which radiates a system of branched membranous tubes, more or less coated with mud or other matters. In young specimens the central shell is absent, and the animal presents the appearance of an irregular system of branches radiating from a centre. The shape of the adults is very various, and depends on the surface to which they are attached; they attain sometimes a diameter of nearly a quarter of an inch, though generally much smaller. The shell is not acted upon by acids,

and is therefore siliceous. The animal itself can seldom be detected, as it lies concealed within its central flinty stronghold and the complicated system of earthworks surrounding it."

The figures (Pl. XXVII.A. figs. 10, 11), are from young specimens; those of larger size are generally found in confused masses, of which it is difficult to distinguish the outline of the various parts.

I have not been able to verify the statement as to the siliceous "shelly" structure of the central chamber, but it is probably of similar character to that of *Dendrophrya erecta*, described in a later paragraph.

At present the only known localities for the species are Old Granton Quarry, near Edinburgh (Wright), and low-tide pools, Cumbrae, Firth of Clyde (Robertson).

Dendrophrya erecta, Str. Wright (Pl. XXVII.A. figs. 7–9).

Dendrophrya erecta, Wright [1861], Ann. and Mag. Nat. Hist., ser. 3, vol. viii. p. 122, pl. iv. figs. 4, 5.

Test consisting of an attached chamber, with one or more erect branching arms. Basal chamber patelloid or spreading, buried in sand or mud; arms rising either from the margin or from the convex surface, taking the form of irregularly-branched chitinous tubes, more or less thickly coated with mud, with pseudopodial apertures at the distal extremities of the branchlets. Height, $\frac{1}{7}$th inch (3·5 mm.).

Dendrophrya erecta is noticed by Dr. Wright in the following terms:—"In this species, found on stones, the branched, membranous, and mud-clothed tubes, instead of creeping over the surface to which the animal is attached, spring upwards and outwards. Delicate pseudopodia, linear and forked, are readily observed to protrude themselves from the extremities of the branches, accompanied sometimes by lobular processes of the sarcode of the animal. The patelloid shell of *Dendrophrya erecta* may be easily detached from its seat, and its tenant, a small patch of semi-transparent sarcode, scooped out with a flat-pointed needle, and transferred to the stage of the microscope. It differs from the sarcode of other Rhizopods in being filled with delicate short fibres instead of the usual molecular matter, and contains, both within the shell and tubes, the highly refractive bodies I have mentioned in a former paper[1] as ova." The figure accompanying this description represents a nearly circular disk, only slightly convex; with half a dozen branching tubes set at about equal distances round the margin. The tubes are not quite erect but slightly spreading; they are depicted of darker colour than the disk, and delicate pseudopodia issue from the distal extremities of all the branches.

The specimens collected by Mr. Robertson at Cumbrae present a great variety of

[1] On the Reproductive Elements of the Rhizopoda, *Ann. and Mag. Nat. Hist.*, ser. 3, vol. vii. (1861) p. 360.

aspects; some have only a single arborescent limb, others have several. When there is only one, it is large, erect, and much branched, and springs from the centre of the patelloid base. The multibrachiate forms have none of the regularity shown in Dr. Wright's figure of the species. The adherent chamber is more often long and spreading than circular, and the arms, though sometimes marginal, are by no means invariably so, but appear to spring from any prominent part of the surface. At the same time there can be little doubt that these different forms, regular and irregular, whether with one branch or several, all belong to a single very variable species.

The shape of the basal chamber depends a good deal upon that of the body to which it is attached. It is almost always more or less encrusted with coarse, brown, sand-grains, but when these are removed, they leave a light, shelly-looking test. As stated by Dr. Wright, this is unaffected by acids, at any rate by strong acetic acid. The texture is so fine that under a low power it appears almost homogeneous; and it is only with a magnifying power of 500 diameters, and with the assistance of polarized light, that its composite arenaceous structure is at all clearly revealed. It is not easy to determine how the sand-grains are incorporated. The investment of the tubes, near their union with the central chamber, though much thinner than that of the chamber itself, exhibits the same structure; and in the tubular portions of the test the sand-grains are certainly embedded directly in the chitinous envelope. The chitinous coat itself is unaffected by acetic acid, and I am disposed to think that the "shell," firm and hard as it is, is formed of very fine sand, selected from the impalpable mud, and incorporated by the chitinous layer without the aid of inorganic cement.

The tubes, except just at the base, are soft and flexible; they collapse on drying and can scarcely be manipulated in fluids, even with a soft brush or needle, without disintegration; hence it is seldom that the terminal apertures (fig. 9) are left entire in preserved specimens. The investment consists of a delicate chitinous membrane, slightly beset with sand, and covered with a thin layer of grey mud. When growing in the vicinity of sponges a considerable number of spicules find their way into the muddy coat; but this rarely occurs, and they are not used as building material in the same systematic fashion as in many other arenaceous Rhizopoda.

This species, as well as the last-described, will probably be found on many parts of the coast when it is looked for; meanwhile, all we know of its distribution is that it has been found by Dr. Wright and Mr. Robertson in pools at low-water, at Old Granton Quarry and at Cumbrae.

Storthosphæra, Schulze.

Storthosphæra, Schulze [1874], Norman, Brady.

This genus is represented by a single species only.

Storthosphæra albida, Schulze (Pl. XXV. figs. 15–17).

Storthosphæra albida, Schulze, 1874, II. Jahresberichte d. Komm. Untersuch. d. deutsch. Meere, p. 113, pl. ii. fig. 9, *a.–d.*
„ „ Norman, 1880, Report Brit. Assoc., Swansea Meeting, p. 390.

Test free, roundish; walls relatively somewhat thick and soft, composed of fine sand only slightly cemented; interior surface smooth; exterior exceedingly irregular, beset with ridges or with tooth-like or sometimes cervicorn outgrowths. No visible aperture. Colour light-grey or greyish-brown. Diameter, $\frac{1}{12}$th to $\frac{1}{8}$th inch (2 to 3 mm.).

Prof. F. E. Schulze has accurately described this singular type in his Report on North-Sea Rhizopoda above referred to, and there is little to add to the details which he has given.

Storthosphæra is closely allied to *Astrorhiza*, especially to such forms as *Astrorhiza arenaria*, from which it differs chiefly in contour and size. The test is composed of fine grey sand; it is somewhat soft and crumbly owing to the comparative absence of cement, and is of a consistence easily cut with a sharp knife. As the interior is rounded and smooth, the thickness of the wall varies a good deal at different parts of the surface. There is no visible orifice, and Schulze has surmised that fine interstitial pores serve the purpose of a general aperture. This view is perfectly reasonable; and, though it is not easily demonstrated, there is collateral evidence that renders the explanation exceedingly probable. In some specimens the summit of the superficial protuberances appears to be of looser texture than the remainder of the test, a circumstance that suggests that these are the parts permeated by the sarcode. A similar condition has already been described in certain varieties of *Astrorhiza*, in which the ends of the rays or branches have no visible orifice, but are found on dissection to be closed only by loosely aggregated sand, leaving ample interstitial space for the passage of the sarcode. In other species of the same genus, of which the habits of the living animal have been observed, the pseudopodia are emitted from the ends of the rays, leaving no doubt as to the normal position of the apertures. The sarcode filling the cavity of the test is described as a greyish-brown mass, appearing granular under high magnifying powers, and containing a multitude of transparent brownish fat globules, similar to those found in *Gromia* and other Foraminifera.

Storthosphæra albida is a rare species; and for the figured specimens I am indebted to my friends Prof. Schulze and the Rev. A. M. Norman. It occurs on the coast of Norway, Bukkenfiord, 365 fathoms (Schulze), and Kors Fiord, 180 fathoms (Norman); in the warm area of the Faröe Channel, 530 fathoms, a single specimen (Murray), and in the Bay of Biscay (Norman). An arenaceous organism of similar size and texture but without superficial excrescences, possibly a worn example, occurred in material from Station 323, South Atlantic, 1900 fathoms; but no satisfactory representative of the type has been met with in the Challenger collections.

Syringammina, H. B. Brady.

Syringammina, Brady [1883].

The genus *Syringammina* has recently been established for certain arenaceous Rhizopods of large dimensions and rounded form, consisting essentially of masses of connected branching tubes radiating from a central point. Our present knowledge of the genus is exceedingly limited, and its salient features will be best understood from the description of the typical species.

Syringammina fragilissima, H. B. Brady.

Syringammina fragilissima, Brady, 1883, Proc. Roy. Soc., vol. xxxv. p. 155, pls. ii. iii.

Test free; consisting of a rounded mass of branching, inosculating tubes, radiating from a common centre, and arranged in more or less distinct concentric tiers or layers, which are marked by the formation at intervals of a network of lateral branches. Walls arenaceous, composed of nearly uniform fine sand, with little or no inorganic cement. Apertures terminal, situated at the peripheral ends of the tubes, closed in with loosely aggregated sand-grains. Colour dark-grey when wet, drying to a much lighter tint. Diameter about $1\frac{1}{2}$ inch (38 mm.).

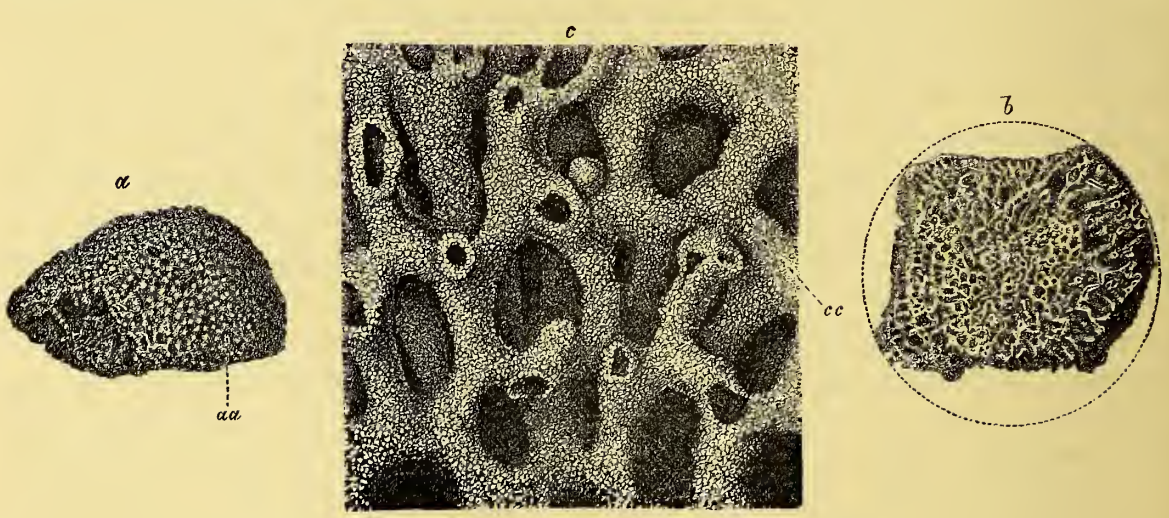

Fig. 9—*Syringammina fragilissima.*

a. Side view of a fragment representing about half an entire specimen. Part of the natural surface is preserved at *a a*. Natural size.

b. Inferior aspect of the same, representing an uneven fractured surface near the middle of the organism. The dotted line indicates approximately the original outline of the test. Natural size.

c. Portion of a radial section; showing at *c c* one of the concentric reticulated partitions. Magnified 8 diameters.

The organisms to which the foregoing description and figures refer were dredged by Mr. Murray in the Faröe Channel, during the cruise of H.M.S. "Triton" in the autumn

of 1882, and they form the subject of a short paper recently published in the Proceedings of the Royal Society (*loc. cit*).

Two specimens were secured, but owing to the excessively fragile nature of the test, both were much broken. The largest fragment is represented in figs. *a*, *b*, drawn to the natural size. This specimen is about an inch and a half (38 mm.) in diameter, and about eight-tenths of an inch (20 mm.) in thickness, but it is probable that the latter dimension may not be much more than half that of the entire organism; indeed, it is evident that the test when complete was a rounded mass, which, if developed with any degree of symmetry, must have been a sphere of about an inch and a half diameter. The structure revealed by the fractured surfaces is that of a congeries of branching and inosculating tubes radiating from a common centre.

The fragile nature of the investment is due to the fact that the walls are composed of fine sand, with scarcely a trace of inorganic cement. In this respect the organism bears a close resemblance to several well-known arenaceous Rhizopods, notably to *Astrorhiza arenaria*, but the difference in size renders the absence of incorporating cement a much more noticeable feature; for whilst the test of the latter species, though loosely arenaceous, has sufficient strength and substance to bear handling without injury, that of the present form will scarcely support its own weight when taken out of water, and crumbles into a mass of sand on the gentlest attempts at manipulation.

The central portions of the test appear to consist of a network of branching and often contorted tubes, of somewhat smaller diameter than those of the exterior, and less regularly disposed. Nearer the periphery the system of tubes takes a distinctly radial character, and in a favourable section appears divided into concentric layers or tiers of gradually increasing depth (fig. *c*). The concentric "partitions" exhibited in the radial section of the test (fig. *c*,—*cc*) are not, like the "labyrinthic layers" of *Parkeria*, continuous septa of cancellated structure, but are formed by lateral tubular branches, given off at intervals, which unite so as to produce a more or less regular network. As nearly as can be made out, there may have been ten or eleven such reticulated "partitions," at intervals varying from $\frac{1}{20}$th inch (1·26 mm.) near the centre, to $\frac{1}{10}$th inch (2·5 mm.) near the periphery.

As already stated, the tubes are not of uniform size, those near the centre measuring sometimes no more than $\frac{1}{50}$th inch (0·5 mm.) in external diameter, whilst near the periphery they sometimes exceed $\frac{1}{25}$th inch (1 mm.), the average diameter being about $\frac{1}{35}$th inch (0·735 mm.). Their external surface is granular, but, in the dry condition, tolerably smooth; the interior is smooth and well finished. The internal cavity, whether of the radial tubes or the branches, is continuous, exhibiting neither constrictions, septa, nor labyrinthic subdivision. The thickness of the walls is about $\frac{1}{200}$th inch (0·125 mm.).

The peripheral ends of the tubes are rounded, and closed by an aggregation of sand-grains of somewhat lighter colour than the rest of the test, in precisely the same way as

in *Astrorhiza arenaria* and its immediate allies. These are shown in the side view (fig. *a*), at the spot marked *aa*.

The tubes of some parts of the test were filled with dark-coloured sarcode, similar in all respects to that found in the tests of many of the larger arenaceous Foraminifera.

Chemical analysis shows that upwards of 53 per cent. of the dry test consists of siliceous sand, and about 35 per cent. of carbonate of lime. The latter item may be accounted for by the presence of a very large number of minute Foraminifera amongst the sand of which the test is built; of secreted calcareous matter there appears to be little or none.

The precise habitat of the specimens is given in the following note from the log of the "Triton":—

"Station 11. August 28th, 1882, lat. 59° 39′ 30″ N., long 7° 13′ W.; depth, 555 fathoms; ooze; surface temperature, 57°·2; bottom temperature, 45°·5 F."

The position is to the west of the Wyville-Thomson Ridge, and close to the "Holtenia Ground" of the "Porcupine" Expedition.

Mr. Murray states that a somewhat similar specimen was dredged at a depth of 1000 fathoms off the Azores, during the Challenger cruise, but that it went to pieces in the sieve.

Sub-family 2. Pilulininæ.

Pilulina, Carpenter.

Pilulina, Carpenter [1870], Brady.

The genus *Pilulina* is at present limited to a single species, as follows.

Pilulina jeffreysii, Carpenter (Pl. XXV. figs. 1–6).

Pilulina, sp., Carpenter, 1870, Descr. Cat. of Objects from Deep-sea Dredgings, p. 5, No. 5.
Pilulina jeffreysii, Id. 1875, The Microscope, 5th ed., p. 532, figs. *d.*, *e.*

Test free, nearly spherical; consisting of a single undivided chamber, the walls of which are composed of felted sponge-spicules and fine sand with no calcareous cement. Aperture a long curved or sigmoid slit, with slightly raised lips. Colour light grey or nearly white. Diameter, $\frac{1}{7}$th inch (3·5 mm.).

This species is perhaps the best type of the series to which it belongs, and exhibits in as marked a manner as any the peculiarities of structure which constitute the salient feature of the entire Sub-family. Evidences of selective power, in respect of the extraneous substances employed in the construction of the test, are not uncommon amongst the arenaceous or composite types of Foraminifera; and nowhere is this faculty more

strikingly displayed than in the group under consideration, in which the investing walls are composed to a great extent of sponge-spicules. Long delicate needles, such as can be felted together, are for the most part employed, and the interstitial spaces are filled with a tolerably compact mass of broken spicula and fine siliceous sand. Whether any cement is used for the incorporation of these materials beyond the sarcode itself, possibly somewhat inspissated on its outer surface, it is difficult to say. The test is soft and somewhat flexible, of just such consistence as might be produced by the mechanical arrangement of bodies like those referred to; it is but little affected by acids, contains no appreciable amount of carbonate of lime, and none of the ferruginous matter which is so common a constituent of the test in the allied arenaceous groups. But, by whatever means it is accomplished, the work is so well done that the interior surface is quite smooth, and the exterior equally neatly though somewhat differently finished.

The aperture in *Pilulina* is a long narrow slit with protruded edges. It is sometimes simply arched, but more frequently has a double curve somewhat resembling the letter S. The sarcodic body of the animal is stated by Dr. Carpenter to be of dark green colour.

Almost the only known specimens of this type are in Dr. Carpenter's collection, and I am indebted to him for the loan of those which are figured in Pl. XXV. They were obtained on the first cruise of the "Porcupine," in the year 1869, at three Stations in the North Atlantic, south of the Rockall Bank, namely, Nos. 21, 23, and 28, depth 1476 fathoms, 630 fathoms, and 1215 fathoms respectively.

Technitella, Norman.

Technitella, Norman [1875], Brady.

"Test elliptical, cylindrical, or subfusiform, composed of the broken fragments of sponge-spicula arranged parallel to the axis, and enclosed entirely, or rarely only partially, in the body-wall. Unattached below and closed. A tubular mouth-opening formed by a contraction for a short distance of the body-walls so as to form a short tube."[1]

I have retained the genus *Technitella* provisionally, though in considerable doubt whether there is any really distinctive character by which it can be separated from *Pilulina*. The structure of the test is practically identical in the two genera, and the difference in contour between such forms as *Technitella melo* and the typical *Pilulina* is too trifling to have any generic significance. There remains only the aperture, which in *Pilulina jeffreysii* is a curved slit with pouting lips, whilst that of *Technitella* is normally a rounded opening, either flush with the surface or in a short constricted neck. But Mr. Norman states that the orifice of *Technitella melo* is "in the form of a slit," which "in

[1] Norman, *Ann. and Mag. Nat. Hist.*, 1875, ser. 5, vol. i. p. 279.

the type is wider at the sides than in the central portion," so that even the aperture appears to be more or less variable in its characters, and in so far non-distinctive.

Technitella melo, Norman (Pl. XXV. fig. 7, *a.b.*).

Technitella melo, Norman, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 280, pl. xvi. figs. 5, 6.

Mr. Norman describes this species in the following terms:—"Test regularly ovoid, broadly and evenly rounded below (aborally); greatest diameter below the middle; above the middle sloped away to the central anterior (oral) opening. Oral opening not markedly extruded or tubular as in *Technitella legumen*, but compressed, so that the opening is in the form of a slit; this slit in the type is wider at the sides than in its central portion. The test is formed of minute linear sponge-spicules, built carefully into the wall, and the interstices filled with the same sort of snow-white cement as in *Technitella legumen*. Instead, however, of the whole of the spicula being entirely built into the body-wall, as in the case of that species, the aboral portion is garnished with scattered acerate projecting spicula, the pointed ends of which are protruded considerably from the body-wall, and are invariably directed backwards. Length, 1·4 mm., breadth, 1 mm." ($\frac{1}{18}$th inch by $\frac{1}{25}$th inch).

Some portions of the above are descriptive of a specimen rather than of the species, and reference to the figure (Pl. XXV. fig. 7), which represents a fairly good example, will show at least that considerable margin must be allowed in many of the characters laid down by the author. The form in this case is a nearly symmetrical oval, the upper and lower portions tapering equally; the surface has but few projecting spicula, and the aperture is a small rounded perforation.

The record of the distribution of *Technitella melo* is limited to two localities. The figured specimen is from one of the Challenger dredgings in the South Atlantic,—Station 344, off Ascension Island, 420 fathoms; and those described by Mr. Norman were from the North Atlantic, south of the Rockall Bank, 1215 fathoms.

Technitella legumen, Norman (Pl. XXV. figs. 8–12).

Technitella legumen, Norman, 1878, Ann. and Mag. Nat Hist., ser. 5, vol. i. p. 279, pl. xvi. figs. 3, 4.

Test free, elongate-oval or subcylindrical, commonly bent or otherwise asymmetrical; superior extremity rounded or truncate, often surmounted by a short, wide, tubular neck or collar, bearing the aperture; inferior extremity round, or more or less tapering and pointed. Aperture a simple round orifice. Colour white or light grey, except when the test is coated with sand. Length, $\frac{1}{10}$th inch (2·5 mm.).

Technitella legumen, like many other monothalamous and monostomous Foraminifera varies exceedingly in external contour; indeed it appears capable of assuming any shape, from a long pointed oval to a curved cylinder with rounded ends. The aperture too varies considerably in different specimens. The broken test (fig. 9) corresponds pretty closely to the characters given by Mr. Norman in the original description, in which it is stated that "the mouth-opening is in the form of a contracted tube," and pursuing the general similitude of the test to a legume, the neck is said to "represent about the same proportional length and width to the cylinder as the basal portion of the pea-pod, where it passes into the calyx, does to the pod itself." Since the publication of the paper referred to, a considerable number of specimens of *Technitella legumen* have come under my notice, and I have found no uniformity in these particulars that would lead me to regard them as furnishing specific characters of any value.

Recently my friend Mr. Robertson of Glasgow has dredged the species in some abundance in the living condition on the west coast of Scotland; and almost the whole of his specimens have a superficial coating of sand or mud. One of them is represented in its natural state in Pl. XXV. fig. 11. The sandy coat is sufficiently coherent to resist ordinary washing, but it can be disintegrated and removed without difficulty, and the characteristic spicular test appears underneath. Whether this is a mere local peculiarity, depending on some exceptional condition of the sea-bottom, or the normal habit of the animal when living, cannot at present be determined; but it is an interesting fact in connection with the tendency exhibited by some other Foraminifera, notably *Truncatulina lobatula*, to protect themselves under certain circumstances with a covering of sand. That in all such cases the material is selected and incorporated by the sarcode enveloping the test, there can, I think, be no doubt.

The distribution of the species, so far as known, is as follows. South of Bukken, Norway, 150 to 200 fathoms; and thirty miles west of Valentia, Ireland, 112 fathoms (Norman); off Cumbrae, 60 to 65 fathoms (Robertson); at two Challenger Stations in the South Atlantic—south of Pernambuco, 350 fathoms, and east of Buenos Ayres, 1900 fathoms; off Christmas Harbour, Kerguelen Islands, 120 fathoms; off Sydney, Australia, 410 fathoms; north of the Society Islands, 2350 fathoms; and lastly, one or two broken specimens in soundings off the Fiji Islands.

Technitella raphanus, n. sp. (Pl. XXV. figs. 13, 14).

Test free, elongate, subcylindrical, straight or somewhat curved; broad near the superior extremity and tapering to a point at the inferior. Aperture a simple round orifice formed by the gradual constriction of the superior end of the test. Length, $\frac{1}{8}$th inch (3 mm.).

All that is known of this species is derived from two specimens, both of them apparently dead tests, a good deal worn and stained. Their salient characters, however, remain well marked, and in point of contour they furnish an interesting modification of the type. The tests have the spicular structure characteristic of the *Pilulininæ*, and the exceptional colour is probably only the brown tinge noticed in the old and dead shells of many Foraminifera that are devoid of colour when living.

The single habitat for *Technitella raphanus* is Station 174, off Kandavu, Fiji Islands, 210 fathoms.

Bathysiphon, Sars.

Bathysiphon (M. Sars, MS.), G. O. Sars [1871], Norman, Brady.

Comprises only a single species, as follows,—

Bathysiphon filiformis, Sars (Pl. XXVI. figs. 15–20).

Bathysiphon filiformis (M. Sars, MS.), G. O. Sars, 1871, Videnask.-Selsk. Forhandl., 1871, p. 251.
„ „ Norman, 1880, Report Brit. Assoc., Swansea Meeting, p. 389.

Test free; consisting of a long narrow, often slightly tapering tube, open at both ends, the exterior usually marked by transverse lines of growth. Walls soft, constructed chiefly of felted sponge-spicules and fine sand, with little or no calcareous cement. Colour light grey or nearly white; old specimens sometimes coated with a brownish deposit. Length indefinite, often 2 inches (50 mm.) or more.

Prof. G. O. Sars's memoir, above referred to, contains a brief notice of this singular type, from specimens dredged by him in the Hardanger Fiord, at a depth of 500 fathoms. The author also states that the species had been previously discovered by his father, Dr. M. Sars, from whom it had received the name under which it appears in his paper. The Rhizopodal nature of the organism is recognised by these distinguished naturalists, but no indication of its zoological or structural characters is furnished, beyond a note of its light colour, and its resemblance at first sight to the tube of an annelid.

The test of *Bathysiphon filiformis* consists of a very long narrow tube, varying but little in thickness from end to end, though sometimes tapering very slightly; generally a good deal curved or bent, and usually white in colour, or very nearly so. The length of the specimens which I have examined ranges from half an inch to two inches (12 to 50 mm.); their diameter from $\frac{1}{70}$th to $\frac{1}{15}$th inch (0·35 to 1·7 mm.). They are all more or less marked with transverse lines, apparently only indicating stages of growth, as there is no material constriction of the tube at these points. Externally the tube is smooth,

and, as already stated, nearly pure white, but in old specimens of large dimensions it is often partially coated by a superficial brownish deposit. The test is more or less flexible, and its consistence is such that it is easily cut with a sharp knife. The interior forms a cylindrical cavity of nearly even diameter, with smoothly finished surface. During life the tube is filled with dark-coloured or almost black sarcode.

The minute structure of the test is closely analogous to that of *Pilulina*. It is composed almost entirely of interlacing sponge-spicules and fine siliceous sand, differing however from *Pilulina* in one point, namely, that the spicules appear to be employed chiefly, though not exclusively, on the inner portion of the wall, the outer surface being made up of finer materials (fig. 18). There is the same apparent absence of cement as in the allied genera, and acids have but little effect on the test. There is no evidence whatever of definitely organised structure, such as would be presented by a sponge; there are no visible pores, and no oscula. Though some selective power is manifestly exercised, there is a wonderful variety amongst the spicula employed in the construction of the test; and Mr. Norman states in a letter on the subject, that in disintegrating a single specimen he has counted as many as nineteen of the forms enumerated in Bowerbank's list, not one of which could be said to be predominant or characteristic.

Bathysiphon filiformis is a rare species, and has only been met with at one Challenger locality, Station 195, off Banda, Amboyna, 1425 fathoms. It appears to be plentiful in the Hardanger Fiord (M. Sars, G. O. Sars, Norman), and occurs in deep water in the Bay of Biscay (Norman, de Folin).

I am indebted to my friend the Rev. A. M. Norman for the specimens figured in Pl. XXVI., as well as for the supply that has enabled me to work out the general characters and structure of the test.

Sub-family 3. Saccammininæ.

Psammosphæra, Schulze.

Psammosphæra, Schulze [1874], Brady, Norman, Haeusler.

Test free or attached, typically spherical, with no visible aperture. Only one species.

Psammosphæra fusca, F. E. Schulze (Pl. XVIII. figs. 1–8).

Psammosphæra fusca, Schulze, 1874, II. Jahresberichte d. Komm. Untersuch. d. deutsch. Meere, p. 113, pl. ii. fig. 8, *a. f.*
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 27, pl. iv. figs. 1, 2.
„ „ Haeusler, 1883, Quart. Journ. Geol. Soc., vol. xxxix. p. 26, pl. ii., fig. 1.

Test free or attached, spherical or nearly so; exterior rough and coarsely arenaceous,

interior smooth; with minute interstitial orifices, but no general aperture. Colour reddish-brown. Diameter, from $\frac{1}{160}$th to $\frac{1}{6}$th inch (0·16 to 4·0 mm.).

This is one of the simplest of the arenaceous Foraminifera. Although by no means uncommon in deep water, it remained undescribed until the publication of Prof. Schulze's memoir above quoted. Fifteen years or more ago I found it in considerable abundance in one of the "Bulldog" soundings obtained by Dr. Wallich, but the specimens were very minute, and in the then existing state of knowledge it was difficult to decide whether they were Foraminifera or not. It has been the custom to consider that the tests of the arenaceous Rhizopoda are of necessity imperforate; in other words, that except the general pseudopodial orifice the investment is non-porous, and the fact of these specimens having no general aperture created a doubt as to their Foraminiferal character. But it is now well understood that the term "imperforate" is only applicable to a limited number of genera, and that some at least of the sandy forms have more or less porous tests, though, owing to their composite texture and the irregularities of the surface, the orifices are but little apparent on the exterior.

Schulze's description of the species is quite accurate as applied to large specimens. They are spheroidal bodies, from two to four mm. ($\frac{1}{12}$th to $\frac{1}{6}$th inch) in diameter, without any perforations visible to the naked eye, commonly free, but occasionally adherent to small stones. The test itself is from ·25 to ·5 mm. thick, and is composed of coarse sand-grains, united by a cement of fine texture and of characteristic grey-brown colour. Whilst the exterior is more or less rough, owing to projecting sand-grains or fragments of stone, the interior is throughout even and smooth (Pl. XVIII. fig. 6), the constituent angular particles being very neatly fitted together and cemented. But in point of size the range is much wider than that suggested by the large North-Sea specimens, and in some areas adult and otherwise characteristic tests scarcely average $\frac{1}{100}$th of an inch in diameter, and are often much smaller.

The tendency of the animal to attach itself to foreign bodies is revealed in many different ways; sometimes a fragment, but little smaller than the remainder of the test, is built into the wall; in other cases the shell is erected, tent-like, upon a stone. In several localities minute specimens like that represented in Pl. XVIII. fig. 4, built upon or around a sponge-spicule, are very common. Occasionally where the species is abundant the spheres are found adhering to each other, and forming what appears at first sight a polythalamous test (Pl. XVIII. fig. 8). It is evident, however, that the connection is purely accidental, and examples do not occur with sufficient frequency to warrant the idea that there is any tendency to associate in colonies as in *Sorosphæra*.

It is somewhat remarkable that, notwithstanding the thickness of the test and its rough composite texture, these sandy spheres are quite translucent when fresh, and retain this character for a long period, when preserved in glycerine or diluted alcohol.

Psammosphæra fusca is a very widely distributed type. Schulze's specimens were obtained from Hougesund, on the coast of Norway, at 120 fathoms; and it has been found in even shallower water on our own shores, namely, off Loch Scavaig, Skye, 45 to 60 fathoms. It nevertheless prefers the deep sea. I have note of its occurrence at ten Stations in the North Atlantic, at depths varying from 440 to 2750 fathoms; at seven Challenger Stations in the South Atlantic, 150 to 2800 fathoms; at the Antarctic Ice-barrier, 1675 fathoms; at one Station in the North Pacific, 185 fathoms; and at two in the South Pacific, 2335 fathoms, and 2375 fathoms respectively.

This species is one of the many interesting arenaceous Foraminifera recently discovered by Dr. Rudolf Haeusler in the Jurassic formations of Switzerland.

Sorosphæra, H. B. Brady.

Sorosphæra, Brady [1879].

Test consisting of a colony of more or less independent inflated chambers, with no general apertures.—Only one species.

Sorosphæra confusa, H. B. Brady (Pl. XVIII. figs. 9, 10).

Sorosphæra confusa, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 28, pl. iv. figs. 18, 19.

Test free, consisting of a number of inflated or spherical chambers of nearly uniform size, irregularly crowded together and adhering to each other by their outer surfaces. Walls thin, finely arenaceous in texture, with minute interstitial orifices. General aperture wanting. Diameter of individual chambers about $\frac{1}{25}$th inch (1 mm.), of the entire colony, variable, sometimes $\frac{1}{6}$th inch (4·5 mm.).

The number of specimens of *Sorosphæra confusa* hitherto met with has not been sufficient to permit of very thorough examination of the test by means of sections and the like, but its general features are tolerably obvious. It consists of a mass of inflated or globular chambers grouped together irregularly, having no connection with each other by distinct stoloniferous tubes, and no general apertures either to the individual chambers or to the collective test. The investment is thinner and less compactly built than in *Psammosphæra*, and there can be little doubt that the interstices amongst the sand-grains of the contiguous chamber-walls are sufficient to afford a certain amount of communication between the segments. The number of chambers varies from three or four to twenty or even more.

The absence of any general aperture may be held to account for the irregular growth of the test, for it is clear that if the protoplasm exude at all points of the surface, a fresh

chamber may be formed whenever sufficient has collected at one spot to segregate itself into a mass of the requisite size.

Setting aside a number of doubtful specimens, *Sorosphæra confusa* has been found at the following points. In the North Atlantic, south of the Rockall Bank, 630 fathoms; Faröe Channel, 542 fathoms; off Drobak, Norway (Carpenter); off the Azores, 900 fathoms; and at one Station in the North Pacific, 2900 fathoms.

Saccammina, M. Sars.

Saccammina, M. Sars [1868], Carpenter, Brady, G. O. Sars, Etheridge, Zittel, Young, Rupert Jones, Norman, Bütschli, &c.

Test free or rarely adherent; consisting of one or several rounded or fusiform chambers with distinct apertures. Polythalamous forms with or without stoloniferous connections between the chambers.

The typical condition of *Saccammina* is represented by a single, free, spherical or pyriform chamber, with compact arenaceous investment and a simple aperture situated in a somewhat produced neck. Recent specimens, as a rule, agree pretty well in all these particulars. The association of a number of such chambers in a sort of colony, so long as they are only adherent by their exterior surfaces and the individual apertures remain distinct, is a comparatively unimportant deviation from the normal state, but more noteworthy exceptions are found in the adherent and polythalamous specimens occasionally met with in localities where the typical form is abundant, and these will be alluded to in a later paragraph.

In the fossil condition *Saccammina* is normally, if not invariably, polythalamous; the chambers instead of being globular or pyriform, are, as a rule, more or less fusiform, and joined end to end by short stoloniferous tubes; though the size of the segments and the structure of the walls correspond precisely with those of the recent type.

Prof. Zittel has figured,[1] under the name *Saccammina schwageri*, a little fossil resembling a single segment of the common Carboniferous species, but with reticulated exterior. Surface-ornament of any sort is exceedingly rare amongst the arenaceous Foraminifera, and unless the figured reticulation is caused by an unusually regular arrangement of agglutinated sand-grains, it is difficult to see how the organism can belong to the present genus. Under the designation "*Saccammina?* (*Calcisphæra*) *eriana*,"[2] Principal Dawson has described certain minute calcareous spheres, plentiful in one of the Devonian limestones of Ohio. Although I have not myself been able to recognise Foraminiferal characters in specimens of the organism kindly transmitted to me by two or three American correspondents, at any rate not with any degree of certainty, I am not

[1] Handbuch der Palæontologie, vol. i. p. 76, fig. 5.

[2] *Canadian Naturalist*, 1880, vol. x. No. 1, p. 5.

disposed to question the opinion of so experienced a microscopist as my friend Dr. Dawson; but supposing the Rhizopod nature of the fossil established, the characters of the shell appear to suggest affinity with the calcareous rather than the strictly arenaceous types.

In localities in which *Saccamminæ* abound, whether in the recent or fossil condition, it not unfrequently happens that almost the entire deposit is composed of their tests. Some of the soundings taken off Franz-Josef Land, during the Austro-Hungarian North Polar Expedition, showed that the sea-bed of that boreal region in many places consists of little else, and in the Carboniferous formation of the north of England and of Scotland, there are certain limestones which are almost exclusively made up of the remains of the polythalamous variety of the type.

The distribution of the genus *Saccammina* is practically embraced in the geographical area inhabited by *Saccammina sphærica* and the geological range of *Saccammina carteri*. The former affects moderately deep water, and is common only in the North Atlantic and Arctic Oceans. The earliest recorded appearance of the latter is in beds of Lower Silurian age at Girvan in Ayrshire (Nicholson and Etheridge), and it is plentiful in some of the Carboniferous limestones of both Great Britain and Ireland. A little uncertainty prevails about its occurrence in Mesozoic rocks, but the genus is stated by Rupert Jones[1] to have been found in the Lias and possibly in the Lower Oolite. From a manuscript list, for which I am indebted to Dr. Rudolf Haeusler, I infer that it has been obtained from the Upper Jurassic beds of Switzerland, though it is not mentioned in his published catalogue.

Saccammina sphærica, M. Sars (Pl. XVIII. figs. 11–17).

Saccammina sphærica, M. Sars, 1868, Videnskab.-Selsk. Forhandl. for 1868, p. 248.
„ „ G. O. Sars, 1871, Ibid. for 1871, p. 250.
„ „ Carpenter, 1875, The Microscope, 5th Ed., p. 532, fig. 272, *a.b.c.*

Test free or rarely attached; globular or pyriform; consisting typically of a single chamber with compact coarsely arenaceous walls, and a simple orifice situated in a nipple-like protuberance. Tests which are (or appear to be) polythalamous have the later segments small, imperfectly formed, and irregularly combined. Diameter from about $\frac{1}{25}$th to $\frac{1}{7}$th inch (1 to 3·5 mm.).

Saccammina sphærica was discovered by the elder Sars, and the name first appears in a list of Foraminifera dredged by him at a depth of 450 fathoms on the coast of Norway. Neither specific description nor figures accompanied this catalogue, but specimens kindly furnished by Prof. G. O. Sars to several subsequent observers leave no doubt as to the form for which the name was intended.

[1] *Proc. Geol. Assoc.*, 1872, vol. ii. p. 181, table.

In its normal condition *Saccammina sphærica* is readily distinguished from most of the other monothalamous species which resemble it in general contour—from the corresponding varieties of *Pilulina*, *Technitella*, and *Pelosina* by its hard rough firmly cemented test, and from *Reophax difflugiformis* by its relatively large size and thicker walls. From *Psammosphæra fusca*, the distinction, which depends primarily on the presence of a distinct aperture, is not so satisfactory, for specimens belonging unquestionably to the genus *Saccammina* are occasionally met with in which the orifice is exceedingly obscure, if not entirely wanting.

In localities where the species is very abundant, the test often assumes anomalous forms. Sometimes individuals, crowded together at the sea-bottom, adhere to each other, in which case they either have separate orifices and remain in fact independent organisms, or, as is more common, they open into each other and constitute a sort of polythalamous test. Occasionally a larger fragment of rock is built into the wall, and the test has the characters of an adherent organism (Pl. XVIII. fig. 14). In polythalamous specimens the additional chambers are smaller than the primordial one, and to some extent, therefore, supplementary; in such cases the sandy investment of the terminal sphere is often incomplete, and shows numerous large openings amongst the sand-grains. An example with some of these peculiarities is represented in Pl. XVIII. fig. 16. The large chamber adhering to two stones is the original test, and the remainder is supplementary, the smaller extremity being a mere mass of sand-grains with large interstitial openings. The chambers are sometimes connected in a straight line, as in the specimen under notice, but more commonly are combined in a less regular manner. The fusiform test, fig. 17, has two orifices, and closely resembles a single chamber of the fossil *Saccammina carteri*. Such variations from the typical form as those which have been described are more or less the result of accidental circumstances, and have little zoological significance.

Saccammina sphærica has been dredged on the coast of Norway—in Hardanger Fiord, Christiania Fiord, off Bergen, off Dröbak, and elsewhere, by M. Sars, G. O. Sars, Norman, and others. Dr. Carpenter's collection contains specimens from ten or more "Porcupine" Stations in the North Atlantic, situated west and south-west of Ireland, at depths of from 173 to 1443 fathoms; and from one point in the Faröe Channel, 542 fathoms. It occurs in eight out of ten soundings made on the Austro-Hungarian Expedition, off the shores of Franz-Josef Land, in latitude 79° to 80° N., depth, 89 to 145 fathoms; and in some of them it was the most abundant Foraminifer. It is reported also from deep water in the Bay of Biscay. It has only been found at two Challenger Stations, No. 246, near the very deep area of the North Pacific, 2050 fathoms, in which locality the specimens were built almost entirely of dead *Globigerina* shells; and Station 155, depth 1300 fathoms, near the Antarctic Ice-barrier, where a considerable number of individuals, indistinguishable from the North Atlantic type, were met with.

Saccammina socialis, n. sp. (Pl. XVIII. figs. 18, 19).

Test consisting of several independent arenaceous chambers, individually spherical or subspherical in shape and of nearly even size, attached to each other by their outer surfaces, but without stoloniferous intercommunication, each chamber having its own external aperture. Spheres seldom more than six or eight in number, and usually arranged with more or less regularity. Texture finely sandy, nearly smooth externally. Diameter of the individual chambers $\frac{1}{30}$th inch (0·8 mm.) or less.

This is a very rare variety, and so far as can be determined from the few specimens which are known, appears to represent a colony of individuals rather than a true polythalamous organism. The chambers are smaller than those of *Saccammina sphærica*, and present a comparatively smooth exterior; the walls are thin and built of nearly uniform fine sand, and the test is grey, or at least devoid of the rich brown colour of the typical species.

Saccammina socialis has only been found at one Challenger Station, namely, No. 246, North Pacific, 2050 fathoms. In Dr. Carpenter's collection are one or two specimens from the North Atlantic, south of Rockall Bank, 1263 fathoms.

Sub-family 4. Rhabdammininæ.

Jaculella, H. B. Brady.

Jaculella, Brady [1879].

Test free, elongate, cylindrical, tapering; aperture at the broad end; texture coarsely arenaceous, rough externally.

Jaculella is only known as a recent genus. The details of its structure and geographical distribution may be gathered from the notes appended to the two species which follow.

Jaculella acuta, H. B. Brady (Pl. XXII. figs. 14–18).

Jaculella acuta, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 35, pl. iii. figs. 12, 13.

Test elongate, tubular, straight or nearly so; closed and pointed at one extremity, gradually increasing in width towards the other, which, slightly constricted and rounded, but otherwise open, forms the general aperture. Texture coarsely arenaceous, very compact and hard; exterior surface rough, interior also rough but in a less degree. Colour rich brown in the earlier portion of the test, becoming gradually lighter towards the wide end. Length very variable, sometimes 1 inch (25 mm.) or even more

It is often exceedingly difficult to determine whether the tubular non-septate tests, so frequently met with in bottom-dredgings and in such diverse forms, have belonged to sarcode-animals or to annelids; and there is unfortunately no character short of those pertaining to the creatures inhabiting them, that can be regarded as positive evidence. Annelid-tubes of the commoner species are easily recognised, and so also are the cylindrical tests of Rhizopoda when they are either septate or labyrinthic, or show a distinct primordial chamber; but many of the specimens alluded to, both arenaceous and porcellanous, present none of these features, and the question must be settled on the basis of analogy and probability.

These remarks apply with some force to the species under notice, which has many of the negative characters referred to. The Rhizopodal nature of the test was originally assumed from two or three facts, each small in itself, but collectively of some weight; namely, the firmly arenaceous texture of the walls; the distribution of the colouring matter which, as in several better known species, is often of a deep reddish-brown in the earlier portions and gradually becomes lighter towards the broad end; and lastly, the roughness of the interior, which would be ill-adapted to the organization and life-conditions of an annelid. More recently the matter has been set at rest by the discovery of a closely allied form with a small distinct primordial chamber.

Under ordinary circumstances *Jaculella acuta* forms a conical tube of about $\frac{1}{3}$rd to $\frac{1}{2}$ an inch (8 to 12 mm.) in length, and $\frac{1}{20}$th inch (1·3 mm.) in diameter at the wider extremity. Specimens of more than double this length are occasionally found, but such examples are of comparatively slender contour, as there is no proportionate increase in the width towards the oral end. The walls of the test are hard and brittle, the constituent sand-grains large and very strongly cemented together. There is perhaps no arenaceous Rhizopod-test of which it is so difficult to make a satisfactory section, and it is possibly owing to its extreme brittleness that large specimens are seldom found with the thin end entire.

Jaculella acuta has been found in the North Atlantic,—in one of the "Valorous" soundings, 1750 fathoms; off the coast of Norway; in St. Magnus Bay, Shetland, 60 fathoms (Norman); and off Cumbrae, 60 fathoms (Robertson). In the South Atlantic it occurs at two Challenger Stations, namely, south of Pernambuco, 350 fathoms, and off Buenos Ayres, 1900 fathoms; in the North Pacific, north of Papua, 2900 fathoms; and in the South Pacific, east of New Zealand, 1100 fathoms.

Jaculella obtusa, H. B. Brady (Pl. XXII. figs. 19–22).

Jaculella obtusa, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 714.

Test long, cylindrical, nearly straight; consisting of a tapering tube, commencing in a small bulbous chamber, and gradually increasing in size to the opposite extremity

which is broad and open. Texture coarsely arenaceous, hard and firmly cemented; exterior rough. Length, $\frac{1}{3}$rd inch (8 mm.).

It is possible that this may be only a local variety of *Jaculella acuta*, from which species it differs chiefly in having a small inflated primordial chamber, instead of terminating in a point. The test is comparatively slender, and not so regularly tapering; indeed it sometimes contracts a little near the oral end, leaving nevertheless a broad open aperture, as shown in fig. 20. The bulbous extremity is often armed with a number of long projecting sponge-spicules. The texture of the test is usually less rough and hard than that of *Jaculella acuta*.

Jaculella obtusa occurs in dredged sands obtained both on the "Porcupine" and the "Knight Errant" Expeditions, from the warm area of the Faröe Channel, at depths of 350 fathoms and 542 fathoms.

Hyperammina, H. B. Brady.

Hyperammina, Brady [1878], Norman, Balkwill and Wright, Haeusler.
Girvanella (?), Nicholson and Etheridge [1878].
Psammatodendron (Norman, MS.) Brady [1881].

Test free or adherent; consisting of a long, simple or branching arenaceous tube, the primordial end of which is closed and rounded; the opposite extremity, which is open and but little if at all constricted, forming the general aperture; interior smooth.

The genus *Hyperammina* is of very general distribution, and in one form or other is found at the sea-bottom over large areas of both northern and southern hemispheres, most of the species preferring deep water. It is more than probable that the Silurian organism to which the provisional name *Girvanella* has been given by Nicholson and Etheridge may be a somewhat minute variety of the type, closely allied to *Hyperammina vagans*; and similar forms more distinctly characterised have been found by Dr. Haeusler in the Jurassic rocks of Switzerland.

Hyperammina elongata, H. B. Brady (Pl. XXIII. figs. 4, 7–10).

Hyperammina elongata (pars) Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 433, pl. xx. fig. 2, *a. b.*
„ „ Id. 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 32.
„ „ Balkwill and Wright, 1882, Proc. R. Irish Acad., 2 ser. (Science), vol. iii. p. 546.

Test free; in the form of a straight or nearly straight, unbranched, subcylindrical tube; primordial end slightly inflated, closed, and rounded; the opposite extremity but little

if at all contracted, constituting the general aperture. Walls comparatively thin, of uniform thickness throughout, compact, and firmly cemented; often rough externally, but sometimes smooth or even polished; interior smooth. Length, $\frac{1}{3}$rd inch (8 mm.) or less.

This species was first described in a short paper on the Foraminifera collected during the North-Polar Expedition of 1875–6, *loc. cit.* The arctic specimens were at that time supposed to be specifically identical with some of much larger size occurring in the "Porcupine" and Challenger dredgings; these however have since been adopted as representatives of a distinct species (*Hyperammina friabilis*), and it has therefore been necessary to amend and somewhat to restrict the zoological characters originally given.

Hyperammina elongata is one of the simplest of the arenaceous Foraminifera. The test, as already stated, consists of a cylindrical tube open at one end and closed at the other, the closed end being round and somewhat swollen. The diameter is nearly uniform, and seldom measures more than $\frac{1}{60}$th of an inch (0·42 mm.) and the length varies from $\frac{1}{8}$th to $\frac{1}{3}$rd of an inch (3 to 8 mm.), but the specimens are hardly ever found complete. The wall is of even thickness throughout, and there is no circumscribed or well defined primordial chamber. The texture is arenaceous, and the constituent sand-grains are firmly cemented together; but the condition of the exterior varies considerably according to the nature of the material employed in the construction of the test—some specimens being rough like *Rhabdammina*, others smooth and polished like *Trochammina*, the generality having intermediate characters. Its small dimensions and slender build, and the comparatively thin and hard walls are sufficient to distinguish the species from *Hyperammina friabilis*.

Hyperammina elongata is almost cosmopolitan. It is found as far north as latitude 79° or 80°, both in Smith Sound and off Franz-Josef Land, at depths of from 80 to 130 fathoms. It has been dredged on our own shores, off Cumbrae and in Portree Harbour (Robertson), and in Dublin Bay (Balkwill and Wright); as well as in both the warm and cold areas of the Faröe Channel, 530 to 540 fathoms. It has been obtained at various Stations in the North Atlantic, at depths of from 410 to 1750 fathoms; in the South Atlantic, 350 to 2200 fathoms; in the North Pacific, 2300 and 3124 fathoms; in the South Pacific, 410 to 1425 fathoms; and lastly, from a single Station in the Southern Ocean, between the Cape of Good Hope and Kerguelen Island, 1570 fathoms.

Hyperammina friabilis, n. sp. (Pl. XXIII. figs. 1, 2, 3, 5, 6).

Hyperammina elongata (pars) Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 433.
„ „ Id. 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 32.

Test free, elongate, subcylindrical, tapering, straight or nearly straight; the wide end closed and rounded, the narrow end somewhat contracted so as to form a simple rounded aperture. Internal cavity commencing with a distinct subglobular chamber at

the broad end, the remainder forming a tube of nearly even diameter. Walls thick and loosely arenaceous ; exterior surface rough, interior tolerably smooth. Length, $\frac{6}{10}$th inch (15 or 16 mm.).

The large arenaceous specimens constituting the present species were originally included with some of the smaller forms under the general appellation *Hyperammina elongata*, but further research has led to the conclusion that both in zoological characters and distribution they pertain to a distinct and easily recognised modification of the type. The following are the more important distinctive features. Average specimens of *Hyperammina friabilis* are of larger dimensions, and in general contour are much broader and stouter than corresponding examples of *Hyperammina elongata;* compare fig. 3 with fig. 7. The consistence of the test in the former is loose, and the sand grains are easily disintegrated ; that of the latter hard and firmly cemented. Comparing the sections, figs. 5 and 6, with fig. 10, the walls of *Hyperammina friabilis* are conspicuously thick and the cavity has a well-marked primordial chamber, whilst *Hyperammina elongata* has uniform and thin walls, and the cavity is only slightly widened at the inferior end. *Hyperammina friabilis* is often of grey rather than brown colour externally, but is more or less stained on the interior surface and around the mouth.

The geographical distribution of *Hyperammina friabilis* is very restricted, as compared with that of *Hyperammina elongata.* Judging from the " Porcupine " collections, it is not uncommon in some parts of the warm area of the Faröe Channel, at depths of from 540 fathoms to 767 fathoms ; and it has been found at two other Stations in the North Atlantic, namely, south of Rockall Bank, 630 fathoms, and off Culebra Island, West Indies, 390 fathoms. In the South Atlantic it occurs at two Stations off the coast of South America, near Pernambuco, 675 fathoms and 350 fathoms respectively ; and lastly, if we except a single broken specimen in one of the dredgings between Australia and New Zealand, at one Station in the Indian Archipelago, off Amboyna, 1425 fathoms.

Hyperammina subnodosa, n. sp. (Pl. XXIII. figs. 11–14).

Test long, cylindrical, constricted at irregular intervals ; primordial end closed and rounded ; opposite extremity, either entirely open or somewhat contracted, serving as the aperture ; the interior forming a tube of uneven diameter, commencing in a subspherical chamber, and more or less distinctly segmented. Walls thick, except at the primordial end, where the test is often comparatively thin ; texture coarsely arenaceous. Length, $\frac{3}{4}$th inch (18 mm.) or less.

The external contour of *Hyperammina subnodosa* is well displayed in Pl. XXIII. fig. 11, which is drawn from a large and characteristic specimen. The repeated constriction of the tube, and the incomplete segmentation of the cavity induced thereby, are

shown in the sectional view, fig. 14. These characters serve to distinguish the species from *Hyperammina friabilis* and *Hyperammina elongata*, in which the tube is either regularly tapering or of nearly uniform diameter.

Out of nine localities at which *Hyperammina subnodosa* has been observed, five are in the North Atlantic, the depths varying from 20 fathoms to 450 fathoms, some of the finest specimens being from as far north as the coast of Greenland. It occurs also in the South Atlantic, off Pernambuco, 350 fathoms; amongst the East Indian Islands, 1425 fathoms; in the North Pacific, 2300 fathoms; and in the South Pacific, near the equator, 2600 fathoms.

Hyperammina vagans, H. B. Brady (Pl. XXIV. figs. 1–9).

Hyperammina vagans, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 33, pl. v. fig. 3.
„ „ Haeusler, 1883, Quart. Journ. Geol. Soc., vol. xxxix, p. 26, pl. ii. figs. 2–6.

Test more or less adherent; consisting of a spherical or oval primordial chamber, opening into a long unbranched tube of nearly even diameter, sometimes partially free, but more commonly spreading in irregular tortuous lines over the surface of shells or stones, or, in the absence of foreign bodies, growing coiled upon itself in irregular masses; the open unconstricted end of the tube serving as the general aperture. Walls thin; texture arenaceous; surface tolerably smooth; colour brown, the primordial chamber usually of darker hue than the tube. Length indefinite; diameter of the tube from $\frac{1}{500}$th to $\frac{1}{120}$th inch (·05 to ·2 mm.).

In some areas the fine arenaceous tubes of this or other similar Rhizopod are found to a greater or less extent on almost every fragment of shell or stone presenting a surface favourable to their growth. It is rarely, however, that the specimens are even approximately complete or perfect; and the primordial chamber being almost invariably wanting, such organisms were for a long time passed over, under the supposition that they were the tubes of parasitic annelids. The tubular portion of the test is of indefinite length, and always seeks some solid basis to spread itself upon, in the absence of which it is occasionally found in little masses formed of irregular coils adherent to each other. The bulbous end is often quite free, projecting above the remainder of the test, from which it does not otherwise differ in external characters, except that it is of a darker reddish-brown colour. There is sometimes a slight constriction or articulation at the point where the chamber joins the tube, as shown in figs. 4 and 5.

Hyperammina vagans differs from *Hyperammina elongata* and *Hyperammina ramosa* in its parasitic habit: from the former also in the great length and tortuous course of the tubular portion, and from the latter in the simple unbranched contour of its

extensions. There is only one common Foraminifer with which it is at all likely to be confounded, namely, *Webbina clavata*, J. and P., but the primordial chamber in that species is a simple, adherent, tent-like, shelly dome, and the tube a semi-cylindrical covering—neither chamber nor tube having any floor proper to itself.

Messrs. Nicholson and Etheridge, in their valuable Monograph of the Silurian Fossils of Girvan in Ayrshire, fasc. 1, p. 23, pl. ix. fig. 24, have described, under the provisional name *Girvanella*, a tubular organism occurring abundantly in little masses in the "Craighead Limestone," with the following generic characters:—"Microscopic tubuli with arenaceous or calcareous (?) walls, flexuous or contorted, circular in section, forming loosely compacted masses. The tubes apparently simple cylinders, without perforations in their sides, and destitute of internal partitions or other structures of similar kind." This description applies in every particular to such specimens of *Hyperammina vagans* as are represented in figs. 7 and 8; and the specific characters which follow agree equally well, except in a single point, namely, that the diameter of the tubes in *Girvanella* is from $\frac{1}{700}$th to $\frac{1}{600}$th of an inch, whereas those of the present species range from $\frac{1}{500}$th to $\frac{1}{120}$th of an inch. Some latitude must be allowed in estimating the characters of a minute fossil belonging to so very remote an age, but it seems scarcely worth while to recognise these trifling differences as a basis of generic distinction.

Hyperammina vagans is a cosmopolitan species. It is found as far north as Spitzbergen and as far south as Kerguelen Island, and occurs in all the great ocean basins. Specimens dredged by the Rev. A. M. Norman, off Oban, on the west coast of Scotland, give it a place in the British fauna. Its bathymetric range is correspondingly wide—from 15 or 20 fathoms in the Arctic Sea, to 2900 fathoms in the North and South Pacific.

Of the probability of its existence as a palæozoic fossil nothing more need be said. Dr. R. Haeusler has been good enough to send me a number of specimens, wanting in nothing but colour, from beds of Jurassic age in the Canton Aargau, Switzerland.

Hyperammina ramosa, H. B. Brady (Pl. XXIII. figs. 15–19).

Hyperammina ramosa, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 33. pl. iii. figs. 14, 15.

Test free; consisting of a subglobular primordial chamber with a tubular extension. Tubular portion branched; relatively wide at its commencement, but narrowing as it becomes divided, the later branches of tolerably even diameter. Texture generally loosely arenaceous; exterior rough, often beset with sponge-spicules. Length indefinite.

This organism never attains the dimensions of the allied *Hyperammina friabilis* or *Hyperammina subnodosa*. The texture of the test is coarse; the surface rough, and usually, though by no means invariably, hispid, owing to the number of adherent, or

only partially incorporated sponge-spicules with which it delights to surround itself. It has a tolerably distinct bulbous primordial chamber, and the tubular limb issuing from it is wide and trunk-like at first, but narrower as it becomes subdivided. The finer ramifications are more uniform in diameter, and are exceedingly thin and fragile. Specimens are seldom obtained in even approximately perfect condition, and very rarely show the initial chamber, but fragments of branching arenaceous tubes, easily recognised as belonging to the species, are exceedingly common in deep-sea material from almost every part of the world. Such fragments are often triradiate, and bear some resemblance in form to *Rhabdammina*, but they are looser in texture, lighter in colour, and smaller than radiate specimens of the latter genus, and the tubular rays are less straight and regular.

The best specimens of *Hyperammina ramosa* hitherto met with occur at one of the "Porcupine" Stations in the North Atlantic, south of Rockall Bank, 630 fathoms, and at one of the Challenger Stations in the North Pacific, 2050 fathoms; but fragments present themselves at depths of from 60 fathoms to 3000 fathoms wherever arenaceous organisms abound. It was one of the species obtained on the Austro-Hungarian North-Polar Expedition, off Franz-Josef Land, at about lat. 80° N.

Broken specimens have been found by Dr. Haeusler, associated with *Hyperammina vagans*, in some of the Jurassic beds of the Canton Aargau, Switzerland.

Hyperammina arborescens, Norman, sp. (Pl. XXVIII. figs. 12, 13).

Psammatodendron arborescens (Norman, MS.), Brady, 1881, Denkschr. d. k. Akad Wiss. Wien, vol. xliii. p. 98, No. 13;—Ann. and Mag. Nat. Hist., ser. 5, vol. viii. p. 404.

Test in the form of an erect branching arenaceous tube growing attached at the base. Basal or primordial portion consisting of a more or less inflated chamber; main stem and branches of nearly even diameter, cylindrical, compactly cemented, nearly smooth externally, and brown in colour. The ends of each branch rounded and contracted, so as leave an irregular orifice with thickened lip. Entire length about $\frac{1}{5}$th inch (5 mm.).

This interesting form was discovered by the Rev. A. M. Norman growing on a polyzoan (*Menipea ternata*) dredged during the cruise of the "Valorous," off Holstenborg, Greenland, at a depth of 20 fathoms, and the name *Psammatodendron arborescens* was at first assigned to it. The original specimen, figured in Pl. XXVIII., was most kindly lent to me by Mr. Norman when it was the only known example that was even approximately perfect. Quite recently however, the species has been found in some abundance by Mr. David Robertson, off Cumbrae, on the west coast of Scotland, and the specimens from that locality elucidate one or two points not previously apparent. The most important of these is that the stem, instead of commencing abruptly in the

tubular form, as was supposed, is generally swollen at the base into a small inflated or subglobular chamber, very similar to that seen in certain species of *Hyperammina*. The careful examination of Mr. Robertson's mountings has, in point of fact, revealed no characters not already provided for in the definition of the genus *Hyperammina*, and on that account the species has been removed to the position it here occupies.

FIG. 10.—*Hyperammina arborescens*, Norman, sp., dredged off Cumbrae.

a. Two specimens growing attached to a stone; magnified 20 diameters.
b. Primordial chamber of another specimen; magnified 20 diameters.

The distinctive features of *Hyperammina arborescens* are the extreme tenuity of the tube, and its nearly uniform diameter throughout, the erect habit, and the dichotomous branching of the stem. These characters, together with its reddish-brown colour and comparatively smooth exterior, are sufficient to separate it from *Hyperammina ramosa* and *Hyperammina vagans*, the only species with which it is likely to be confounded.

But little is known of the area of the geographical distribution of *Hyperammina arborescens*, and it is not improbable that, when it is sought for, it may turn out to be a very common species. Mr. Norman's specimen, as already stated, was obtained off Holstenborg (Knight Islands), Greenland, 20 fathoms[1]; Mr. Robertson's, in muddy sand dredged in the channel between Cumbrae and Bute, 50 fathoms; and Mr. Wright reports the occurrence of fragments on the coast of Donegal, Ireland. Broken specimens have also been found in soundings from the shores of Novaya Zemlya and Franz-Josef Land, as well as in material from one of the Challenger Stations in the South Atlantic, namely, off Pernambuco, 350 fathoms.

Marsipella, Norman.

Proteonina, Carpenter [1869].
Marsipella, Norman [1878], Brady, Bütschli, Carpenter, Haeusler.

Test free, fusiform, or nearly cylindrical, with an aperture at each extremity; walls thin, firmly cemented, sometimes composed entirely of sponge-spicules, but more frequently of coarse sand and sponge-spicules, in variable proportions.

Mr. Norman's account of the genus *Marsipella*[2] is to some extent provisional. It is based upon the typical fusiform species, but apparently on an insufficient range of specimens; and the descriptive characters have required considerable modification.

Marsipella elongata, Norman (Pl. XXIV. figs. 10–19).

Proteonina, sp., Carpenter, 1869, Proc. Roy. Soc., vol. xviii. p. 60;—1875, The Microscope, 5th Ed., p. 533, figs. *d.e.f.*
Marsipella elongata, Norman, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 281, pl. xvi. fig. 7.
„ „ Carpenter, 1881, The Microscope, 6th Ed., p. 561, figs. *d.e.f.*

Test elongate, irregularly curved or crooked, more or less fusiform; consisting of a cylindrical tube, tapering and drawn out towards the extremities. Walls thin; central portion, where the test is widest, formed almost exclusively of coase sand-grains; the narrow, tubular ends built of sponge-spicules laid together longitudinally and firmly cemented. Maximum length, about $\frac{1}{4}$th inch (6 mm.).

This striking species was one of many arenaceous Foraminifera new to science, obtained by Dr. Carpenter on the "Lightning" Expedition of 1868, and was originally assigned by him to Williamson's now disused genus *Proteonina*. The description and figure subsequently published by the Rev. A. M. Norman (*loc. cit.*) appear to be founded on a defective specimen. When complete the two ends of the test taper almost equally, and, as a

[1] Not from the "Coast of Norway," as stated, through inadvertence, in the Report on the Foraminifera of the Austro-Hungarian Expedition, *loc. cit.*

[2] *Ann. and Mag. Nat. Hist.*, ser. 5, vol. i. p. 281.

rule, both are drawn out so as to form long narrow tubes, the open extremities of which serve as pseudopodial apertures; but owing to their tenuity and fragile nature, one or both of the tubular terminations are very commonly found more or less broken and imperfect. There is considerable variety in the shape of the test, which is scarcely ever even approximately straight, but is bent and twisted in the most capricious manner, as well as in the proportionate length and width of the specimens. In short examples the length, compared with the width in the broadest part, is in the proportion of 4 to 1; whilst in the slender forms the width is sometimes only one-seventeenth of the length.

With a few rare exceptions, the minute structure of the test presents tolerably uniform characters. The walls are always thin and firmly cemented, and rough externally. In the broad central portion they are constructed of coarse sand, with only here and there a sponge-spicule, as represented on an enlarged scale in figure 18. Small specimens are occasionally found exhibiting this sandy structure from one end to the other, as in figures 16 and 17, but they are quite exceptional, and as a general rule the narrow tubular extremities of the test are built almost exclusively of acerate sponge-spicules.

Marsipella elongata is essentially a North Atlantic species, notwithstanding a few specimens that have been collected elsewhere. It is abundant in the warm area of the Faröe Channel, at depths of from 440 fathoms to 542 fathoms; it is also common on the Rockall Bank, 54 fathoms, and still more plentiful at a Station somewhat further south, 630 fathoms, and again west of Valentia, 808 fathoms; it occurs off Gomera, Canary Islands, 620 fathoms; and off the Azores, 900 fathoms. In the South Atlantic it has been met with at a single Station, south of Pernambuco, 350 fathoms; and in the South Pacific, the record of its occurrence is confined to a solitary specimen at Station 192, off the Ki Islands, 129 fathoms, and two or three from a sounding off Kandavu, Fiji Islands, 210 fathoms.

Marsipella cylindrica, H. B. Brady (Pl. XXIV. figs. 20–22).

Marsipella cylindrica, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 714.

Test consisting of a slender tube of nearly uniform diameter, but seldom straight; constructed almost exclusively of acicular sponge-spicules, either entire or in fragments, laid side by side and forming irregular more or less interlacing tiers, the whole firmly cemented together; the open ends of the tube serving as the aperture. Length indefinite; the longest of the figured specimens $\frac{1}{4}$th of an inch (6 to 7 mm.) or more.

Amongst the Arenacea from the warm area of the Faröe Channel, dredged during the cruise of the "Knight Errant," were a number of these delicate spicular tests. They are tubes of tolerably even diameter, seldom exceeding $\frac{1}{4}$th inch in length, and ranging from

$\frac{1}{200}$th to $\frac{1}{100}$th of an inch (0·12 to 0·25 mm.) in breadth, and are manifestly only portions of an organism that might be developed almost indefinitely. There can be no doubt of their close relationship with *Marsipella elongata*, which was abundant in the same locality. Similar fragments had previously been found during the examination of the "Porcupine" dredgings, and less characteristic specimens at two or three of the Challenger Stations.

The species has been observed in the following localities:—Faröe Channel, 530 fathoms and 542 fathoms ("Porcupine" and "Knight Errant"); South Atlantic off Buenos Ayres, 1900 fathoms; South Pacific off Kandavu, Fiji Islands, 210 fathoms; and off Juan Fernandez, 1375 fathoms.

Rhabdammina, M. Sars.

Rhabdammina, M. Sars [1868], Carpenter, G. O. Sars, Norman, Brady, Bütschli, Haeusler.
Rhabdopleura, G. M. Dawson [1870], Norman.

Test free, tubular; radiate, irregularly branched or rectilinear; with or without a central chamber; the open ends of the tube or its branches forming the apertures; walls firmly cemented, exterior rough.

The genus *Rhabdammina* embraces a very natural and well-defined group of deep-sea arenaceous Rhizopods, of which the best-known variety possesses a radiate test formed of three, four, or five tubes, of about the same diameter, diverging at nearly equal angles from a small central chamber. In addition to the typical stellate form, there are certain straight varieties, which may be regarded as two-rayed modifications of the type, either possessing a central chamber, or in its absence exhibiting a sort of spurious segmentation of the tube; and others with asymmetrically branching tests, which differ from the radiate in the ramification taking place from various parts of the surface, instead of from a single central point. The test is almost invariably built of coarse siliceous sand firmly incorporated, and presents a rough, hard exterior.

Rhabdammina is essentially a deep-water genus. Setting aside two or three exceptional cases in a long list of localities, its bathymetrical range extends from 350 fathoms to 2400 fathoms.

Rhabdammina abyssorum, M. Sars (Pl. XXI. figs. 1–13).

Rhabdammina abyssorum, M. Sars, 1868, Videnskab.-Selsk. Forhandl., 1868, p. 248.
" " Carpenter, 1868, Proc. Roy. Soc., vol. xvii. p. 172.
" " G. O. Sars, 1871, Videnskab.-Selsk. Forhandl., 1871, p. 251.

Test free, radiate; consisting typically of a small central chamber, with tubular arms of nearly even diameter diverging at equal angles on the same plane, the free open ends

of the rays serving as apertures. Walls coarsely arenaceous, very firmly cemented; exterior rough, internal surface smooth. Dimensions very variable, ranging from about $\frac{1}{7}$th to $\frac{2}{3}$rds inch (3 to 17 mm.) from point to point.

Rhabdammina abyssorum was one of several new species of Foraminifera enumerated by the late Prof. Michael Sars in his list of animals dredged in deep water off the coast of Norway. Of these and many other marine invertebrata discovered by the lamented Norwegian naturalist, no description was published, and their identification is due to the kindness of his son Prof. G. O. Sars in distributing type specimens.

Some idea of the variety of form assumed by the test may be gathered from Pl. XXI., but it would require a much longer array of figures to illustrate fully the polymorphic tendencies of the species. Its salient morphological features are described by Dr. Carpenter[1] in the following terms :—

"What is most remarkable, is the geometrical regularity of its form, which is typically *triradiate* [figs. 1, 2], the rays diverging at equal angles from the central cavity, and each being a tube with an orifice at its extremity. Not unfrequently, however, it is *quadri-radiate* [figs. 3, 4], the rays diverging at right angles; and occasionally a fifth ray presents itself, its radiation, however, being on a different plane [fig. 7]. The three rays are normally of equal length; but one of them is sometimes shorter than the other two; and when this is the case, the angle between the long rays increases at the expense of the other two, so that the long rays lie more nearly in a straight line [fig. 8]. Sometimes the place of the third ray is indicated only by a little knob; and then the two long rays have very nearly the same direction. We are thus led to forms in which there is no vestige of a third ray,[2] but merely a single straight tube, with an orifice at each end; and the length of this, which often exceeds half an inch, taken in connection with the abundance in which it presents itself in dredgings in which the triradiate forms are rare, seems to preclude the idea that these long single rods are broken rays of the latter."

Little need be added to the foregoing clear exposition, which, though written on the basis of specimens collected from a comparatively limited area of the North Atlantic, is for the most part equally applicable to those obtained from other parts of the world. It may be remarked, however, that in the quadri-radiate tests the arms are not always arranged at right angles (see fig. 6); and in the five-rayed specimens, the tubular arms though often irregular, as shown in fig. 7, are nevertheless sometimes disposed on one plane, as in figs. 5 and 11.

Occasionally ramose tubes, like fig. 9, are met with in localities where *Rhabdamminæ* abound. Such specimens probably belong to an allied species referred to by Dr. Carpenter in his notes on some of the Foraminifera procured on the "Lightning" Expedition, under

[1] The Microscope and its Revelations, 6th Ed., 1881, p. 562.—The references in brackets apply to figures in Pl. XXI. of the present Memoir.

[2] The *Rhabdammina discreta* of the present Report, Pl. XXII. figs. 7–10

the name *Rhabdammina irregularis*.[1] I am informed by the Rev. A. M. Norman that a variety with branching arms was also obtained in the dredging operations of "le Travailleur" in the Bay of Biscay, in 1880.

The walls of the test are composed chiefly of coarse sand, the grains of which are of various sizes, and taken apparently without much selection (figs. 12, 13). The nature of the mortar employed for incorporating the siliceous material cannot be positively stated, but chemical analysis reveals the fact that, next to silica, peroxide of iron is the largest constituent of the test, and in the absence of any considerable proportion of carbonate of lime, it is fair to conclude that the cement is, to a greater or less extent, a ferruginous compound. Be this as it may, the resulting wall is hard and compact, and forms as strong and effective a protection as a thick homogeneous shell. The test is invariably coloured, but the precise tint differs in different localities. In the North Atlantic it takes various light shades of reddish-brown, whilst at certain points in the East Indian seas it is of much darker hue, sometimes almost black; the difference in fact between fig. 13 and fig. 12. The colouring matter appears to be in part organic.

The area of the geographical distribution of *Rhabdammina abyssorum* is almost world-wide. The most northerly points are the shores of Franz-Josef Land, about lat. 80° N., 108 fathoms, and Barents Sea, 219 fathoms. Of its presence in the Arctic Ocean, Prof. G. O. Sars states in a letter to the author, that in the region lying east of Finmark, Bear Island, and Spitzbergen, the typical stellate form exists in such abundance as to render the term Rhabdammina ooze not inappropriate for the dredged mud. It is found on the coast of Norway, 450 fathoms (M. Sars); in the Hardanger Fiord, 500 fathoms (G. O. Sars); in the Gulf of St. Lawrence, 220 fathoms (Whiteaves); in deep water in the Bay of Biscay (Norman); in the warm area of the Faröe Channel, 305 to 542 fathoms; south of the Rockall Bank, 630 fathoms; south-west of Ireland, 862 fathoms and 2435 fathoms; off the Canaries, 1125 fathoms; and at two Stations near the Azores, 900 fathoms and 1000 fathoms. In the South Atlantic it has only been noticed at one Station, east of Buenos Ayres, 1900 fathoms. Its southern limit, so far as our present knowledge extends, is Station 146, lat 46° 46′ S., between the Cape of Good Hope and the Kerguelen Islands, 1375 fathoms. In the South Pacific it occurs off Sydney, 410 fathoms; off Amboyna, 1425 fathoms; and off the north coast of Papua, just under the equator, where it is exceedingly abundant, 1070 fathoms.

Rhabdammina discreta, H. B. Brady (Pl. XXII. figs. 7–10).

Rhabdopleura, sp., G. M. Dawson, 1870, Canad. Nat., vol. v. N. S., p. 176, woodcut, fig. 7.
Rhabdammina discreta, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 48.

Test cylindrical, open at both ends; consisting of a straight or nearly straight tube of indefinite length, spuriously segmented by slight constrictions at irregular intervals.

[1] *Proc. Roy. Soc.*, 1869, vol. xviii. p. 60.

Walls comparatively thin, composed of angular sand-grains, firmly cemented; interior smooth. Length sometimes 1 inch (25 mm.) or more.

The long arenaceous tubes of *Rhabdammina discreta* closely resemble the arms of the typical *Rhabdammina abyssorum;* they are of about the same diameter, and the minute structure of the test in the two species is indistinguishable. But, whilst the individual rays of the latter species are of nearly even diameter throughout, the tube of *Rhabdammina discreta*, in addition to its indefinite length, is marked by external constrictions, which give to it a more or less nodose character. Sometimes an example is met with like that represented in fig. 8, in which one joint is swollen till it resembles the central chamber of *Rhabdammina linearis*, suggesting the idea that the imperfect segmentation of the tube in some way takes the place of the radiate division of the test in the typical form. Specimens with this peculiarity are readily distinguished from *Rhabdammina linearis*, in which it is a constant feature, by their comparatively large size, darker colour, and firmer texture, as well as by the transverse constrictions already described.

Rhabdammina discreta occurs in company with *Rhabdammina abyssorum*, though not invariably present even where the latter species is plentiful. Its occurrence has been recorded at seven Stations in the North Atlantic, varying in depth from 410 fathoms to 1750 fathoms; at two in the South Atlantic, 350 fathoms and 1900 fathoms respectively; at one in the western area of the North Pacific, 2475 fathoms; and at four in the South Pacific, 1075 fathoms to 2160 fathoms. The bathymetric range of these fourteen localities lies between 350 and 2475 fathoms, indicating clearly that the home of the species is in deep water. Nevertheless in the far north, off the coast of Greenland, it occurs at a depth not greater than 20 fathoms, and in the far south, off Kerguelen Island, at 120 fathoms, so that probably the distribution is more or less affected by the temperature of the sea-bottom.

Rhabdammina linearis, H. B. Brady (Pl. XXII. figs. 1–6).

Rhabdammina linearis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 37 pl. iii. figs. 10, 11.

Test free, linear, straight or bent; consisting of an oval central chamber, with two long tubular arms, one at each end, projected in the same line; tubular portion often irregular in width; wall of the central chamber thinner than that of the arms; aperture formed by the free ends of the tubes. Length, $\frac{1}{4}$th inch (6 or 7 mm.).

Since the provisional description of this species was written (*loc. cit.*), a number of additional specimens have been found, and some amendments have become needful in the characters accorded to it.

The test is altogether of smaller dimensions than those of average examples of the

typical *Rhabdammina abyssorum*. The material employed for its construction is a fine light-coloured sand of even grain, the general appearance of which, under a magnifying power of 60 diameters, is shown in Pl. XXII. fig. 6. The superficial texture, as displayed in this figure, exhibits a strong contrast to that of the comparatively roughly built test of *Rhabdammina abyssorum*, represented in figs. 12 and 13 of the previous plate. The walls, though moderately firm, are neither so hard nor so compactly built as those of the type, owing to the comparative absence of the highly-coloured cement which binds together the coarse sand employed by the latter species.

The two arms are not always of the same diameter, and they vary a good deal in contour in different specimens. Sometimes they taper a little towards the oral extremities, but as frequently preserve a nearly even width, and occasionally become slightly wider near the ends. The apertures and the test in their immediate vicinity, are generally tinged reddish-brown.

Rhabdammina linearis is known as far north as the mouth of the Hardanger Fiord, Norway, 126 fathoms (Mr. Norman's collection), and has been noted at three other points in the North Atlantic, namely, off the west coast of Ireland, 816 fathoms, off Sombrero Island, West Indies, 450 fathoms, and off Culebra Island, West Indies, 390 fathoms. It occurs at two Stations in the South Atlantic,—off Pernambuco, 675 fathoms, and east of Buenos Ayres, 1900 fathoms; and at two in the South Pacific,—east of New Zealand, 1100 fathoms, and off Amboyna, 1425 fathoms.

Rhabdammina cornuta, H. B. Brady (Pl. XXII. figs. 11–13).

Astrorhiza cornuta, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 43, pl. iv. figs. 14, 15.
Rhabdammina cornuta, Id., 1882, Proc. Roy. Soc. Edin., vol. xi. p. 714.

Test free, asymmetrical, outspread or rounded; consisting of a central wider tube (sometimes shortened so as to form an irregular inflated chamber), with lateral arms or branches at irregular intervals, not radiating from one point; branches either terminating in rounded apertures, or furnished with protruding simple or bifurcating chitinous tubes, which serve the same purpose. Walls composed of coarse sand-grains, firmly cemented together; exterior very rough. Length of the larger specimens about $\frac{1}{4}$th inch (6 mm.).

This species was originally assigned, with some reservation, to the genus *Astrorhiza*, owing to the resemblance in contour of the larger specimens to the branching variety of *Astrorhiza arenaria;* but its minute structure accords so much better with the general characters of *Rhabdammina* that it has been transferred to its present position. In point of fact it bears something like the same relation to the typical *Rhabdammina abyssorum* that the branching specimens of *Astrorhiza arenaria* bear to the regularly stellate forms.

The test assumes very various shapes, but it is always more or less asymmetrical, and has tubular branches diverging from different points without regularity. The walls are of the same coarse hard texture as those of the typical species. It is one of the few arenaceous Foraminifera in which the chitinous lining immediately surrounding the sarcode is sometimes found protruding beyond the apertures of the test, a condition well shown in figs. 11, 12.

Rhabdammina cornuta has been observed at five localities, three of which are in the North Atlantic, namely,—south of the Rockall Bank, 1215 fathoms, off the west coast of Ireland, 816 fathoms, and in the warm area of the Faröe Channel, 532 fathoms. The remaining two are Challenger Stations:—No. 122, South Atlantic, south-east of Pernambuco, 350 fathoms; and No. 168, east of New Zealand, 1100 fathoms.

Aschemonella, H. B. Brady.

Astrorhiza, pars, Norman [1876], Brady.
Aschemonella, Brady [1879], Bütschli.

Test free; consisting either of a number of segments arranged in single or branching series, or of a spuriously segmented branching tube; chambers tubular or inflated, unequal in size and irregular in contour, generally presenting numerous stoloniferous apertures. Walls arenaceous, comparatively thin, firmly cemented.

The characteristic features of the genus *Aschemonella* are the great variety of shape exhibited by the segments, their irregularity and want of symmetry, and the extreme tenuity of the walls of the test in comparison with the bulk of the sarcode-cavities, especially in the larger specimens. It is almost the only genus of the *Astrorhizidæ* in which really segmented, polythalamous tests are the rule. It will save repetition to notice these and other peculiarities in connection with the typical species, *Aschemonella catenata*.

Aschemonella is essentially a deep-water type, and finds its most congenial home at depths of from 1500 to 2900 fathoms.

Aschemonella catenata, Norman, sp. (Pl. XXVII. figs. 1–11, Pl. XXVII, A. figs. 1–3).

Astrorhiza catenata, Norman, 1876, Proc. Roy. Soc., vol. xxv. p. 213.
,, ,, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 42, pl. iv. figs. 12, 13.
Aschemonella scabra, Id. Ibid. p. 44, pl. iii. figs. 6, 7.

Test free, irregularly branched; chambers numerous, inflated, variable in size and contour, usually with several tubulated orifices, each of which may produce a fresh seg-

ment. Walls thin, compactly built; exterior more or less rough, often acerose with partially embedded sponge-spicules; interior smooth. Complete specimens sometimes $\frac{5}{12}$th inch (10·5 mm.) in length.

The examination of Mr. Norman's specimens of *Astrorhiza catenata*, one of which is represented in Pl. XXVII. fig. 3, has led to the conclusion that they are small examples of the same polymorphic species that was subsequently described by myself under the name *Aschemonella scabra*. Nevertheless, the thin hard investment and the general contour of the chambers are sufficient to separate the type they exemplify from *Astrorhiza;* so that, whilst accepting Mr. Norman's specific name, the generic term *Aschemonella* must still be retained for them. Mr. Norman's description, as well as my own, was founded on disjointed segments, and until quite recently the features of the entire organism were a matter of conjecture. Further search, however, amongst material from the locality whence most of the specimens figured in Pl. XXVII. were obtained, has yielded two or three complete tests, drawings of which are given in Pl. XXVII. A, figs. 1–3.

These specimens help to explain the wide diversity of form exhibited by the fragments previously collected, and in a general way to confirm the characters originally attributed to the species. The number of segments however in the complete test, in fig. 2, for instance, is far in excess of what could have been anticipated; and it is still probable, judging by the contour of some of the disjointed fragments previously found, that there may have been considerable individual differences in this particular. Nor does there appear to be any uniform rule as to the mode of combination. In fig. 1 (Pl. XXVII. A.) the primordial segment is the largest; in fig. 2, the earliest segment is the smallest and the rest increase successively in size until the test begins to branch, after which they diminish somewhat. The branching takes place exactly as might have been foretold: a number of segments are first formed in single moniliform series, then the terminal chamber produces two or more tubulated apertures at its distal extremity, each of which gives rise to a new segment.

The drawings, Pl. XXVII. figs. 1–11, give some idea of the polymorphic character of the segments, but are far from exhausting the wonderful variety of odd shapes they assume. It may be noticed that one of them has no less than six stoloniferous tubes, each of which has probably communicated with a distinct chamber. In point of size the variation is equally striking, the individual segments ranging from $\frac{1}{75}$th to $\frac{1}{5}$th inch (0·33 to 5 mm.) in length.

The walls of the test are remarkably thin,—thinner perhaps than those of any other type of arenaceous Rhizopods, in comparison with the bulk of the sarcode lobes they have to support. They are constructed of very fine sand firmly cemented, and do not appear to be lacking in strength. The comparative rarity of unbroken specimens is chiefly due to the slenderness of the stoloniferous tubes. In the fresh condition there is a considerable

amount of flexibility in one of the long, many-jointed tests, but when dry the narrow sutures become exceedingly brittle.

When first taken out of alcohol some of the specimens were in the condition represented in Pl. XXVII. A, fig. 3, coated with mud, and they were scarcely recognised as pertaining to the same organism. It was found on examination that the mud was a loose accessory coating, which could be removed with a soft brush, and that underneath was a sandy test similar to fig. 1 or 2. It is manifest that even a thin layer of compact mud, filling in the inequalities of the surface, must afford great protection to a slender, jointed test like that which has been described. In these specimens each terminal lobe had a brush-like tuft of sarcode-filaments at the oral end, showing that they had been dredged in the living condition.

The distribution of *Aschemonella catenata* appears to be governed by bathymetrical rather than geographical conditions. Its habitat includes seven Stations in the North Atlantic, ranging from the entrance to Davis Strait (the locality of the specimens originally described by the Rev. A. M. Norman) to within a few degrees of the equator; the depths varying from 390 to 2740 fathoms; one Station in the South Atlantic, east of Buenos Ayres, 1900 fathoms; one in the South Pacific, off Kandavu, Fiji Islands, 210 fathoms; and three in the North Pacific, from 1850 to 2900 fathoms. The average depth of the twelve Stations enumerated is 1800 fathoms. By far the finest series of specimens is that from Station 244, in the deep area of the North Pacific.

Aschemonella ramuliformis, n. sp. (Pl. XXVII. figs. 12–15).

Test free, elongate; forming an irregular, more or less branched, sometimes segmented tube, with numerous apertures, lateral and terminal. Walls very thin, but hard and firmly cemented; exterior only slightly rugose, interior surface smooth. Length, $\frac{1}{3}$rd inch (8 mm.).

The long branch-like forms of *Aschemonella* appear at first sight very distinct from those which consist of a number of inflated chambers united by stoloniferous tubes; but in reality they are not easily separated, and at best the distinction is of no more than varietal significance.

The test in this variety takes the form of a tube with irregular outline; sometimes branched, but more frequently having the aspect of a bough with the branches lopped off, the "scars" bearing rounded orifices. There is sometimes a constriction at the point where a branch joins the stem, as shown in the section, fig. 15, and in so far the test is polythalamous. The exceeding thinness of the walls in comparison with the size of the cavity is well illustrated in the transparent section, fig. 14, which also exemplifies the comparatively smooth condition of both the exterior and interior surface of the test.

Aschemonella ramuliformis occurs in the two localities at which the typical species is most abundant, namely, Station 244, in the deep area of the North Pacific, 2900 fathoms, and Station 323, in the South Atlantic, east of Buenos Ayres, 1900 fathoms; and fragments have also been found in the material dredged at Station 272, in the South Pacific, a little south of the equator, 2600 fathoms.

Rhizammina, H. B. Brady.

Rhizammina, Brady [1879].

Test free, tubular, simple or branching, flexible; texture chitino-arenaceous, more or less rough externally.

The characteristic feature of the genus *Rhizammina* is its chitinous or chitino-arenaceous investment; or, in other words, the large excess of organic over inorganic constituents in the composition of the test. The flexibility of the long tubular body distinguishes it from the more strictly arenaceous types such as *Hyperammina*, in which the walls are composed almost exclusively of inorganic materials so firmly cemented that the slenderest specimens are rigid and non-elastic.

The minuter characters of the investment have been worked out, chiefly in connection with *Rhizammina algæformis*, owing to the plentiful supply of that particular form obtained at one of the Challenger Stations; but so far as the structure and composition of the test are concerned, the description of the branched variety applies equally to the unbranched forms, and is to this extent an epitome of generic characters.

Rhizammina algæformis, H. B. Brady (Pl. XXVIII. figs. 1–11).

Rhizammina algæformis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 39, pl. iv. figs. 16, 17.

Test free, tubular, branching dichotomously, flexible, forming tangled weed-like tufts of indefinite size. Texture chitino-arenaceous, rough externally; colour of the tube when free from incrustation, brown.

Amongst the doubtful microscopic organisms which have from time to time been dredged in deep water in various parts of the world, minute, branching, flexible tubes, with somewhat rough exterior owing to partially embedded sand-grains, have not been the least frequent. These have hitherto occurred in comparatively small numbers, and though they have been supposed to belong to the Rhizopoda, their precise nature has been but little studied. A number of specimens were obtained by Dr. Carpenter in 1869, in the deepest portion of the North Atlantic explored during the "Porcupine" Expedition of

that year; but at one of the Challenger Stations off the western coast of South America, in about the latitude of Valparaiso, the principal part of the contents of the dredge consisted of a weed-like organism of this sort.

The appearance of the specimens varies according to the nature of the sea-bottom whence they have been obtained. Those from the North Atlantic, kindly lent to me by Dr. Carpenter, are from a Globigerina ooze; those from the South Pacific from a "grey mud," containing a few Foraminifera and a good many Radiolaria. Reference to some of the figures in Pl. XXVIII. will show the effect of local conditions in modifying the external characters of the test. Thus, fig. 2 is from the grey mud, and fig. 3 from the Globigerina ooze—the magnifying power being the same in both cases; and figs. 6 and 7 are smaller pieces more highly magnified. Notwithstanding the number of adherent *Globigerina*-shells and the like, the Atlantic specimens retain their flexibility. Specimens as different as those represented in figs. 2 and 3 are indistinguishable from each other in point of structure after they have been decalcified with weak acid, both having the appearance of light-brown chitinous tubes: so that the adherent objects, whether *Globigerinæ* or sand-grains, are manifestly a non-essential portion of the investment. I have therefore preferred to base the description of the species on specimens obtained from the South Pacific habitat, not only because the supply of material is larger, but because the proper test is less obscured by incrustation.

Referring again to the plate,—fig. 1 represents a bit of the organism from the latter locality, drawn to the natural size; and fig. 2 an enlarged representation of one of the younger and more transparent branches, magnified 8 diameters. At first sight the tangled threads bear considerable resemblance to masses of some Melanospermous Alga, such as *Stilophora rhizodes;* but, quite apart from the fact that the animal was observed whilst still in fresh condition, the structure of the investment of the preserved specimens is sufficient to determine its Rhizopodal affinities.

When a little tuft is spread out on a white surface, it is seen to be composed of branching tubes, varying in diameter from $\frac{1}{200}$th to $\frac{1}{80}$th of an inch (0·126 to 0·315 mm.). What their original length may have been it is impossible to say, but it is seldom that pieces can be separated of more than an inch or an inch and a half in length. There is nothing to lead to the supposition that the organism may have been sessile or rooted to any foreign body when in the growing state, indeed in places where it is most abundant the indications are all the other way; and nothing resembling a primordial chamber, such as is found in the branching varieties of *Hyperammina*, has ever been observed. The branching is dichotomous, but, beyond this, does not take place on any regular plan. The branches are of even diameter and regular outline, and bear no trace of segmentation.

Notwithstanding the flexibility and apparent softness of the tubes, the proportion of organic matter they contain is relatively very small. A mass of the "weed," thoroughly washed to free it from soluble salts, and dried at 100° centigrade, left 87·6 per cent.

of ash after ignition, and this was almost entirely composed of silica. When living, or in the fresh condition, the relative amount of inorganic material would necessarily be a good deal smaller; but the quantity of moisture normally present in the test cannot be estimated from specimens which have been preserved for a long period in alcohol. Under the microscope the appearance of the tubes is such as would lead to the idea that the chitinous or organic basis formed a much larger proportion of their entire weight. The arenaceous constituents consist partly of minute angular sand-grains embedded in the chitinous envelope but sufficiently exposed to impart a distinct roughness to the exterior, and partly of the empty siliceous tests of Radiolaria, which are present in considerable numbers in the mud of the sea-bottom at this particular locality.

Boiling in water has no appreciable effect on the organism in the condition in which it has come into my hands, that is, after long maceration in alcohol; and moderately strong acetic acid produces no perceptible change in it, even on the application of heat.

Heated in dilute hydrochloric acid (one part of acid to four of water), there is at first a slight effervescence, the carbonic acid being evolved from a few minute Foraminifera built into the test rather than from any secreted calcareous matter, of which there appears to be little or none. After a time most of the tubes break up, and eventually become entirely disintegrated, owing apparently to the solution of the organic matter. In those which remain the test appears as a colourless sandy envelope, and the sarcode, which has swollen to its original size, as a granular, transparent, brown mass, filling the cavity of the tube, as shown in figs. 9, 10.

With nitric acid (one part of acid to four of water), the disintegration is much more rapid, and after a time there is but little residue beyond the siliceous material originally embedded in the test.

Treated with solution of caustic potash and heated, the tubes are considerably disintegrated, but in a different way. Those that have retained their form are split and empty, as though the contents had swollen to bursting before being dissolved out, as seen in fig. 11. Digestion was not carried far enough in these cases to affect the siliceous constituents, and what remains therefore is chiefly the inorganic portion of the investment.

At one of the localities in which *Rhizammina* is plentiful there occurs in company with it an organism in some respects similar, but generally taking the form of little rosettes. It was at first thought that this also might belong to the Rhizopoda; the more so, as some of the branches had the appearance of subdivision into chambers; further examination, however, has led to the belief that the structure is cellular, and that it pertains to the vegetable rather than to the animal kingdom. Fragments of Polyzoa and other similar organisms are often found entangled amongst the branches of *Rhizammina* when it is brought up in the weed-like masses already described.

The Challenger Station alluded to, at which *Rhizammina algæformis* was so abundant,

is No. 299, lat. 33° 31′ S., long 74° 43′ W., between the Island of Juan Fernandez and the western coast of South America, depth, 2160 fathoms. It occurs also, but in nothing like the same profusion, at the next Station, a little further west, depth 1375 fathoms. The figured North Atlantic specimens are from the "Porcupine" Station No. 37, depth, 2435 fathoms. I have notes also of the occurrence of the species in two other localities in the North Atlantic, at depths of 630 fathoms and 1125 fathoms respectively; at two points between the Cape of Good Hope and the Kerguelen Islands, 1570 fathoms and 1375 fathoms; at two in the South Pacific, namely, off Kandavu, Fiji Islands, 210 fathoms, and close to the equator, 2425 fathoms; and at one Station in the North Pacific, 2900 fathoms.

Rhizammina indivisa, n. sp. (Pl. XXIX. figs. 5–7).

Test free, cylindrical, flexible; consisting of an unbranched chitino-arenaceous tube, often tapering towards the ends. Apertures terminal. Length, $\frac{1}{3}$rd inch (8 mm.), more or less.

Flexible unbranched tubes, the investment of a Rhizopod to all appearance closely allied to the species last described, not unfrequently present themselves in dredged material, especially in Globigerina ooze from moderate depths. Our knowledge of these forms is as yet very slight, and all that can at present be done is to describe their salient characters, and to furnish a name by which they may be identified. Some specimens of the sort referred to are figured in Pl. XXIX. figs. 5–7.

The test is cylindrical and seldom straight; it generally tapers towards the extremities, one or both of which may occasionally be found with a constricted mouth, but more frequently in preserved specimens the ends are broken or collapsed. The chitinous envelope is of brownish colour, and comparatively slender, but it is encrusted with *Globigerinæ* or other foreign bodies, often to a considerable thickness. The exterior of the test is always rough, and sometimes transversely wrinkled, as in fig. 7.

Characteristic specimens of *Rhabdammnia indivisa*, coated with *Globigerinæ*, occur in the Faröe Channel, 540 fathoms; others, encrusted with siliceous or calcareous sand, off the Cape of Good Hope, 150 fathoms; off Kandavu, Fiji Islands, 210 fathoms; and elsewhere.

There are yet other membranous tests, such as those represented in Pl. XXIX. figs. 1–3, of which it is impossible to say more than that, when fresh, they appear to be filled with dark-coloured granular protoplasm, and are therefore in all probability Rhizopods nearly related to *Rhizammina*. The tests consist of delicate, slightly-coloured, chitinous or membranous tubes, from $\frac{1}{250}$th to $\frac{1}{30}$th inch (0·1 to 0·8 mm.) in diameter, and of indefinite length, sometimes naked and sometimes surrounded by a thin loose coating of mud which is easily removed, the membrane itself being transversely marked or

wrinkled. Another variety, fig. 4, has a somewhat thicker investment closed at one end, and the surface is often beset with short sarcode-filaments, which, being apparently less mobile and retractile than true pseudopodia, remain extended in specimens preserved in alcohol. These and some other obscure chitinous forms must be left for future investigation.

Sagenella, H. B. Brady.

Sagenella, Brady [1879], Bütschli.

Test an adherent, branching, reticulated, arenaceous tube, with terminal apertures.

Amongst the minute parasitic organisms often found in great abundance on stones and shells dredged from the sea-bottom, especially in the shallow waters of the tropics, there are many of which it is difficult to decide the zoological origin. Some of the most problematical of these take the form of simple or branching tubes, the structural features of which are not unfrequently further obscured by a rough sandy exterior.

There are already many well-known, adherent, tubular Foraminifera of arenaceous texture, some of which like *Hyperammina vagans* are simple and undivided, whilst others like *Placopsilina* and *Bdelloidina* are more or less distinctly segmented. The specimens on which the genus *Sagenella* has been founded, differ from these in important particulars: from *Hyperammina*, in that they have no primordial chamber, but branch indefinitely on all sides, and from the Lituoline genera in the absence of segmentation. The frequent inosculation of the tubes is also a very distinctive feature.

So far as my observation goes, specimens with these characters are rare, and considerable care is needful in separating them from bodies of very different origin. Since the publication of the provisional description of the present genus several specimens, supposed to be related to the figured species, have been sent to me for identification, not one of which could be recognised with any certainty as Foraminiferal. The organisms most frequently confounded with it have been the branching or reticulated creeping stolons of certain genera of Hydroida; but other minuter dendritic creatures of various sorts, both animal and vegetable, have also at times been assigned to the group, and new species proposed for their reception.

Sagenella frondescens, H. B. Brady (Pl. XXVIII. figs. 14, 15).

Sagenella frondescens, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 41, pl. v. fig. 1.

Test adherent; consisting of long, finely arenaceous, tubular passages, ramifying and forming a sort of irregular network over the surface of shells or other bodies. Branches bifurcating; each final branchlet terminating in a neatly rounded aperture. Colour white to very light brown. Size indefinite; diameter of the larger passages about $\frac{1}{60}$th inch (0·4 mm.), of the smaller branches $\frac{1}{200}$th inch (0·12 mm.).

This singular little organism occurs amongst the Nullipore débris of shallow water in the South Pacific, in company with other parasitic Rhizopods, such as *Placopsilina*, *Planorbulina*, and *Truncatulina*. Instances of Foraminifera, either free or adherent, with distinctly reticulating test are exceedingly rare; but it is not difficult to understand how the inosculation of the passages takes place. The branches commonly bifurcate at their extremities, and each fresh branchlet after growing about a thirtieth of an inch, more or less, divides again in the same way; so that however irregular the growth, the sarcode projecting from the different apertures must occasionally meet, and when this occurs the ends coalesce; the investment being formed as growth proceeds, a more or less reticulated condition of necessity results. The test is finely arenaceous, and it appears to be really tubular; that is to say, it is not a mere tent-like covering without a floor proper to itself, like that of *Webbina*. It grows in little patches a quarter of an inch or more in diameter, of white or yellowish-brown colour. The ends of the branches are seldom perfect, owing to their fragile nature, but when they have been accidentally protected and remain complete they present smooth, slightly contracted, rounded apertures formed of clear shell-substance uncoated with sand.

The best specimens of *Sagenella frondescens* have been found on Nullipores and fragments of shell dredged off the Admiralty Islands, at a depth of from 16 to 35 fathoms. A similar, perhaps identical, organism occurs off Tongatabu, Friendly Islands, 18 fathoms; but the specimens lack distinctive characters.

Botellina, Carpenter.

Botellina, Carpenter [1869] Bütschli, Brady.

As only a single species has hitherto been assigned to the genus *Botellina*, and our knowledge of the type is still far from complete, no attempt need be made to separate generic from specific characters.

Botellina labyrinthica, H. B. Brady (Pl. XXIX. figs. 8–18).

Botellina, sp., Carpenter, 1869, Proc. Roy. Soc., vol. xviii. p. 444;—1870, Descr. Cat. of Objects from Deep-sea Dredgings, p. 4, No. 3.

Botellina labyrinthica, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 48.

Test arenaceous; cylindrical, straight or slightly curved, somewhat irregular in outline; one end round and more or less swollen (the natural condition of the other end not certainly known). Wall of the test of firm consistence and compactly built, except at the rounded extremity, where it becomes a thin and incomplete layer of sand-grains with many interstitial openings. Interior of the tube subdivided irregularly by a labyrinth of coarse sandy partitions, except the rounded terminal cavity, which forms an undivided chamber. Length, judging from the broken specimens, 1 inch (25 mm.) or more; diameter about $\frac{1}{8}$th inch (3 mm.).

This fine species was obtained in some abundance at a single Station on the third cruise of the "Porcupine" in 1869, and has never since been met with, though dredging has been repeatedly carried on in the same or closely adjacent localities.

The appearance of the test is that of a brown, arenaceous, cylindrical tube, of somewhat irregular diameter, one end rather swollen and rounded, the other end always imperfect, apparently broken. At the broad end the investment is thin and incomplete, and there are many orifices left between the sand-grains; and this fact, together with the broken condition of the specimens, has given rise to the supposition that when living the test is erect and sessile, growing attached or rooted by its narrower extremity to some fixed base, and that the interstitial orifices of the terminal chamber serve as the general aperture. This may perhaps be the correct explanation of the facts of the case, nevertheless one or two of the specimens have a chitinous tubular extension of the narrow end, only slightly beset with sand, which suggests at any rate that this portion is the growing-point of the organism.

The cavity of the tube, as stated by Dr. Carpenter (*loc. cit.*), "is not divided into chambers by interposed septa as in *Lituola* [*Reophax*], but it is continuous throughout, though traversed in every part of its length by irregular processes, built up partly of sand-grains and partly of sponge-spicules. These arenaceous processes lie in the midst of the sarcodic body, which fills the whole of the cavity without any division into segments, and which communicates with the surrounding medium, at what appears to be the free extremity of the tube, by irregular spaces left between the agglutinated sand-grains that form a rounded termination which nearly closes it in."

The habitat of *Botellina labyrinthica* at present includes only the "Porcupine" Station No. 51, a point lying on the border line between the warm and cold area of the Faröe Channel, concerning which the following particulars are given:—Lat. 60° 6′ N., long. 8° 14′ W.; depth, 440 fathoms; surface temperature, 51°·6; bottom temperature, 42° Fahr.

Haliphysema, Bowerbank.

Haliphysema, Bowerbank [1862], Schmidt, Parfitt, Hæckel, Kent, Norman, Brady, Lankester, Moebius, Siddall, Bütschli.
Squamulina, Carter [1870], Kent.
Gastrophysema, Haeckel [1877].

Test columnar; growing attached by an expanded, convex, spuriously segmented base. Column straight, irregularly curved, or crooked; either simple or divided into a number of branches; gradually increasing in diameter towards the apex, or with swollen bulbous extremities. Walls arenaceous, generally beset with sponge-spicules, especially near the extremities. Aperture terminal.

After long controversy as to its true zoological position, to which allusion is now

happily unnecessary, the genus *Haliphysema* has been assigned by general consent to the arenaceous Rhizopoda.

The fact that no specimens pertaining to the genus have been found in the collections to which the present Report immediately refers, together with the completeness with which its structure and affinities have already been worked out, render any extended account of it superfluous. At the same time it appears desirable that the two recognised species should be figured amongst the arenaceous forms to which they are most nearly allied, and that their characters should be sufficiently described to ensure their easy identification. For particulars as to their minute structure and morphology the student will naturally consult the writings of Carter, Saville Kent, Ray Lankester, and Moebius, in which the subject is treated with an amount of detail that would be out of place here, and with graphic illustrations on a scale that would be equally unfitting. Free use has been made of the memoirs alluded to in the brief descriptions which follow, as well as of the recently published supplementary volume of Bowerbank's "British Spongiadæ," in which the Rev. A. M. Norman has summarised the whole matter, and has likewise furnished a complete synonymy of the members of the group.

For the figured specimens I am indebted to my friends H. J. Carter, F.R.S., and the Rev. A. M. Norman.

Haliphysema tumanowiczii, Bowerbank (Pl. XXVII, A. figs. 4, 5).

Haliphysema tumanowiczii, Bowerbank, 1862, Phil. Trans., p. 1105, pl. lxxiii. fig. 3.
„ „ Id. 1864, Monogr. Brit. Spong., vol. i., pl. xxx. fig. 359; —1866, vol. ii. p. 76.
„ „ O. Schmidt, 1866, Die Spong. d. Adriat. Meeres, 2tes Suppl., p. 13, fig. 13.
„ „ Parfitt, 1868, Trans. Devon Assoc. Sci. Lit. and Art.;—Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 88.
Squamulina scopula, Carter, 1870, Ann. and Mag. Nat. Hist., ser. 4, vol. v. p. 310, pl. iv.;—1877, Ibid., vol. xx. p. 337;—1878, Ibid., ser. 5, vol. i. p. 172;—1879, Ibid., vol. iii. p. 407.
Haliphysema primordiale, Hæckel, 1877, Biolog. Studien, p. 180, pl. ix.
„ *tumanowiczii*, Id. Ibid. p. 192.
Gastrophysema dithalamium, Id. Ibid. p. 196, pls. xii.–xiv.
„ *scopula*, Id. Ibid. p. 206.
Squamulina scopula, Kent, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 1.
Haliphysema tumanowiczii, Norman, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 274.
„ „ Kent, 1878, Ibid. vol. ii. p. 68, pls. iv. v.
„ „ Lankester, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 475, pl. xxii.
„ „ Norman, 1882, in Bowerbank's Brit. Spong., vol. iv. p. 33.

Test consisting of an unbranched tubular column springing from an adherent disk. Disk convex, spuriously segmented; column straight or variously contorted, narrow at the base, and gradually increasing in diameter towards the distal end, which is either broad

and rounded, or takes the form of an inflated or bulbous capitulum. Walls thin, arenaceous, more or less beset with sponge-spicules, especially at the distal end. Length, about $\frac{1}{20}$th inch (1·3 mm.).

This interesting little organism, with its sessile columnar test bristling with borrowed spicules, was not unnaturally classed by its discoverers amongst the Spongiadæ; indeed at first sight the only feature likely to suggest a doubt as to the propriety of the position assigned to it was its comparatively diminutive size. But little was known twenty years ago of sessile Foraminifera, and as little of the composite tests of the arenaceous types; and their frequent preference for sponge-spicules as a building material, was scarcely even thought of until the "Lightning" Expedition of 1868 and the first "Porcupine" Expedition of the following year, made us acquainted with such forms as *Marsipella* and *Pilulina*. In justice to Dr. Bowerbank, to whom we are indebted for the early descriptions of *Haliphysema*, it should be said that he recognised to some extent its anomalous structure viewed as a sponge, both with respect to the peculiar characters of the "expanded base," the preponderance of broken spicula, and the presence of grains of sand and other extraneous matter in the composition of the investment. These facts, though duly set forth, were explained away or left unexplained; at any rate they do not appear to have created in the mind of the author any misgivings as to the conclusions he had arrived at. It was left for Mr. Carter, some years later, to demonstrate the Foraminiferal nature of the type, and for subsequent observers, some controversy notwithstanding, to confirm his exposition in all its more important particulars.

The test of *Haliphysema tumanowiczii* consists of two tolerably distinct portions, the expanded base and the column or pedicel.

The base is a convex or tent-like disk, from $\frac{1}{120}$th to $\frac{1}{80}$th inch (0·2 to 0·3 mm.) in diameter, which in the normal position is attached by its inferior or flat surface to some foreign body such as stone, sea-weed, or zoophyte. Its interior cavity, without being distinctly segmented, is more or less subdivided by irregular radiating partitions, as shown in fig. 5.

The pedicel or column varies much in contour. At the point of union with the expanded base it is thin and slender, and it gradually increases in width as it approaches the distal end. The figures 4 and 5 represent average specimens, in which the increase in diameter is tolerably rapid and the resulting tests clavate in form, with broad rounded ends. But frequently the column remains of nearly uniform diameter, or increases but slightly in width as it grows; and in these cases it forms a long and often much contorted tube, which expands suddenly near the end into an inflated or subglobular head. Rarely the clavate specimens have two or three transverse or oblique constrictions, at irregular intervals; but they are too slight and too variable to have much significance, and as they are not observed at all in the long slender varieties the interior of the column may be said to form a continuous non-segmented tube.

The walls, both of the expanded base and the pedicel, are composed of sand, sponge-spicules, or other foreign bodies, according to the nature of the sea-bottom and the material it affords. The extraneous matter of whatever sort is pretty uniformly distributed and firmly incorporated with calcareous cement, except just at the narrow end of the pedicel, where the test is left in a chitinous and to some extent flexible condition. Notwithstanding the variety of materials employed in the construction of the test, there is a manifest preference for siliceous spicules, and in localities where sponges abound, their long slender needles, either broken or entire, are selected for the purpose. Sometimes the whole exterior of the test, both disk and pedicel, is covered with spicula to the exclusion of sand-grains, as shown in one of Prof. Lankester's drawings (*loc. cit.*): it may be added, however, that the figure referred to is taken from a somewhat exceptional specimen. The selected spicula, whole or broken, are either incorporated in the same way as other foreign materials or are fixed by one end, leaving the remainder free and projecting; and they are generally found in the largest number about the distal end of the test. In some specimens, especially in those with a globular head, they stand out on all sides and at every angle; but in the typical clavate form of *Haliphysema tumanowiczii* they are more frequently all directed forwards, spreading but slightly, so that the broad end has the appearance of a little broom, as represented in the figures.

With respect to the geographical and bathymetrical distribution of *Haliphysema tumanowiczii*, I can add but little to what has already been published. The species appears to be at home in shallow water, from shore-pools or between tide-marks, to a depth of 20 fathoms (Kent), or 25 fathoms (Tumanowicz). The following localities, with two exceptions, are quoted from Dr. Bowerbank and Mr. Norman:—off Hastings (Tumanowicz); Berwick Bay (Johnstone); Cullercoats ? (Alder); Torbay (Parfitt); Budleigh-Salterton (Carter); Jersey (Kent); Colwyn Bay (Siddall); Dublin Bay (Haddon); Bergen, Norway (Haeckel); "*Haliphysema primordiale*," Corsica (Haeckel); "*Gastrophysema dithalamium*," Smyrna (Haeckel).

Haliphysema ramulosum, Bowerbank (Pl. XXVII, A. fig. 6).

Haliphysema ramulosa, Bowerbank, 1864–1866, Monogr. Brit. Spong., vol. ii. p. 79,—vol. iii. pl. xiii. fig. 1.
„ „ Carter, 1870, Ann. and Mag. Nat. Hist., ser. 4, vol. v. p. 389.
Squamulina scopula, "branched variety," Carter, 1870, Ann. and Mag. Nat. Hist., ser. 4, vol. vi. p. 345.
Haliphysema capitulatum, Moebius, 1876, Tagsblatt d. 49, Versamml. d. deutsch. Naturforsch. in Hamburg, p. 115, No. 2.
„ *ramulosum*, Haeckel, 1877, Biolog. Studien, p. 193.
„ „ Norman, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 275;—1882, in Bowerbank's Monogr. Brit. Spong., vol. iv. p. 38.
„ *tumanowiczii*, Moebius, 1880, Foram. von Mauritius, p. 72, pl. i. figs. 1–5; pl. ii. fig. 1.

Test consisting of one or more branching tubular columns springing from an adherent base. Basal portion convex, spreading, or tubular; column straight or irregularly bent, of nearly uniform diameter; branches ascending, somewhat thinner than the column, the distal extremity of each swollen or subglobular. Walls thin, arenaceous, beset with sponge-spicules, especially near the distal extremities. Height, from the base to the summit of the branches, $\frac{1}{10}$th to $\frac{1}{4}$th inch (2·5 to 6 mm.).

The test of *Haliphysema ramulosum* is generally of much larger dimensions than that of *Haliphysema tumanowiczii*, but the distinctive character of the species is the branching habit of growth. The length of the column before the first subdivision takes place, and the number of branches produced, are alike variable. In Dr. Bowerbank's original figure the columns are short and have no more than three or four branches apiece; in the specimen now figured,[1] Pl. XXVII, A. fig. 6, the column is abnormally long, and exhibits sixteen or seventeen terminal heads.

An even more striking peculiarity than the branching habit is the growth of several pedicels from the same expanded base, a feature well represented in the original figure. The beautiful drawings in Prof. Moebius' memoir, referred to in the synonymy, which have been assigned by the Rev. A. M. Norman to this species rather than to *Haliphysema tumanowiczii*, admirably illustrate the same multiple condition. In Dr. Bowerbank's plate, which represents a fragment only, the base is apparently tubular,—a sort of creeping stolon giving off the erect pedicels at intervals; but Moebius figures, *loc. cit.*, pl. i. fig. 3, a specimen with a convex base very similar in character to that of *Haliphysema tumanowiczii*, only more outspread, from which spring three columns, one of them simple and undivided, a second with two branches, and the third with three branches. It by no means follows that this is an invariable condition, and there is nothing to show whether the large multiramose specimen figured in Pl. XXVII, A. had originally an independent foot, or was one of several pedicels attached to a common basal chamber. Until more is known of the structure of the basal portion in cases where there are a number of columns, and of the connection subsisting between them, it is difficult to say whether the collective test should be regarded as a colony, or as an individual organism, of which the columns are analogous to the branching arms of some other arenaceous Foraminifera.

With respect to the minute structure of the walls of the test, the particulars already given in the description of the type apply equally to the present species. The projecting spicules, especially those that beset the distal extremities, are not directed forwards in a brush-like tuft, as commonly seen in the clavate forms of *Haliphysema tumanowiczii*, but radiate in all directions.

Mr. Carter informs me that in habitat, not less than in mode of growth,

[1] This is the specimen alluded to by the Rev. A. M. Norman,—Monogr. Brit. Spongiadæ, vol. iv. p. 38.

Haliphysema ramulosum differs from *Haliphysema tumanowiczii;* that on the coast of Devonshire the former "always grows on the rocks at half-tides, and is therefore uncovered by water twice a day; while the latter grows always in the Laminarian zone, and is seldom or never uncovered." This is an interesting fact, but it is probably of local rather than general application.

I can add nothing to the notes on distribution furnished by previous authors, which may be summarised as follows :—Budleigh-Salterton, Devon, between tide marks (Carter); Guernsey, dredged 15 fathoms, on *Gorgonia verrucosa* (Norman); Roundstone Bay, Ireland, on seaweed, Laminarian zone (Norman); coast of Florida, U. S. A., dredged by Pourtales (Schmidt); Mauritius, coral-reefs (Moebius).

Family IV. LITUOLIDÆ.

The composite structure of the test is the primary characteristic alike of the Lituolidæ and the Astrorhizidæ. No hard line of separation can be drawn between the two Families, but, speaking in general terms, the tests of the Lituolidæ assume more regular forms, their segmentation is more definite, and they are of smaller dimensions, than those of the allied series. The Family, as now presented, embraces a large number of generic or subgeneric groups, which collectively cover an area of morphological variation wide enough to include sandy isomorphs of a considerable proportion of the hyaline and porcellanous types. Our knowledge of the series, especially of the forms constituting the Lituolinæ and Trochamininæ, has been greatly extended by the deep-sea explorations carried on during recent years, and their zoological treatment has of necessity been placed on a wider basis than heretofore. Messrs. Parker and Jones classed the rougher Arenacea known to them as varieties of a single typical species, *Lituola nautiloidea*, and the smoother series, in the same way, as modifications of *Trochammina squamata*. It is needless to enter into the question of the exact zoological value of the minor characters of the numerous organisms now referred to these two subordinate groups, but they are sufficiently distinctive to furnish the groundwork of an orderly classification on similar lines to those adopted in other groups of Foraminifera of like extent. Whether *Reophax*, *Haplophragmium*, and *Placopsilina*, and their labyrinthic isomorphs, be considered as sub-typical varieties of the "species" *Lituola nautiloidea*, as sub-genera of the genus *Lituola*, or as genera of the sub-family Lituolinæ, is a matter that may be determined by convenience. Viewed in relation to the comparative fixity of characters existing amongst animals of higher organization, the first method of treatment would be most consistent, but in relation to the conditions which obtain amongst the Rhizopoda the last of the three presents the fewest difficulties.

The precise nature of the composite test of the Lituolidæ differs considerably in the

four Sub-families, genera and species exhibit minor peculiarities of structure, and even individual specimens are more or less affected in this respect by local conditions. This diversity of structure depends partly on the sort of foreign matter employed in the construction of the test, and partly on the cement secreted by the animal for its incorporation.

Notwithstanding a certain amount of selective power, the nature of the foreign material depends more or less on the character of the sea-bottom. Siliceous sand is the most common extraneous constituent; but on some sea-bottoms, as for instance in pure Globigerina ooze, siliceous grains are rare, and the dead shells of the smaller Foraminifera are used in their stead (Pl. XXX. fig. 13). In the tropics, siliceous sand is often replaced by the calcareous débris of the coral-reefs (Pl. XXX. figs. 15–17); and in like manner the tests of Radiolaria and the frustules of Diatomaceæ are sometimes employed in considerable numbers where such organisms abound. The preference for sponge-spicules, broken or entire, as a building material, which is so conspicuous a feature of certain genera of the Astrorhizidæ, exists in like manner amongst the Lituolidæ, though not to the same extent (Pl. XXXI. figs. 16, 17, &c.).

But the physical characters of the test are also influenced, and perhaps to an even greater degree, by the mode in which the foreign constituents are combined. Under all circumstances the superficial portion of the sarcode, whether in the form of a distinct chitinous envelope or of a less completely differentiated layer, is the basis of the investment. In some cases this of itself is sufficient to serve as the matrix for the arenaceous particles, but much more frequently inorganic matter is collected or secreted by the animal in quantity large enough to make a kind of cement or plaster, in which the foreign particles of whatever sort are embedded. The cement varies very much, both in quantity and chemical composition, but its principal constituent is generally either carbonate of lime or peroxide of iron. In rare instances silica or some siliceous compound is employed, either by itself or in conjunction with other mineral substances.

In the Sub-family Lituolinæ the test is constructed of coarse materials, and, as compared with the allied groups, the sand is proportionately in excess of the cement; nevertheless, the cement is present in sufficient quantity to produce tolerably strong and substantial walls, though the exterior is rough and sometimes wears an unfinished appearance. The principal exceptions to the typical Lituoline structure are found amongst the Nodosariform species. In *Reophax sabulosa* the cement is deficient in quantity, and the test is thick and crumbling. In *Reophax nodulosa* the incorporating medium is more or less siliceous,—sometimes to such a degree that large specimens, half an inch or an inch in length, preserve their form after all the calcareous and ferruginous constituents have been removed by means of strong acids, and still retain sufficient firmness to bear handling without injury. In *Reophax membranacea* the investment is little more than a brown membrane with sufficient calcareous matter and siliceous grains to

make it brittle. In certain genera of the LITUOLINÆ the visible test or skeleton is supplemented and strengthened by the extension of the walls into the interior, in the form of irregular ramifying secondary septa, constructed like the remainder of the test of cemented sand-grains. This subdivision of the chamber-cavities is characteristic of the genera *Lituola*, *Haplostiche*, and *Bdelloidina*.

Amongst the TROCHAMMININÆ a very different rule prevails. The typical test is composed of exceedingly fine sand with an excess of cement; and the walls are thin, well finished, and smooth externally. Sometimes amongst the larger species a few projecting sponge-spicules mar the otherwise even surface, but more commonly the test is perfectly smooth and glossy, and, unlike that of the Lituoline forms, might be spoken of with propriety as a "shell." The most important divergence from the typical structure occurs in the case of certain *Trochamminæ* which inhabit brackish water. In estuarine pools, and other localities where the proportion of saline constituents in the water is less than in the open sea, the tests of the *Trochamminæ* become less calcareous, and this diminution may continue until the investment is little more than a chitinous envelope, so thin and flexible that it collapses on being taken out of fluid and allowed to dry.

Of the structure of the ENDOTHYRINÆ it is necessary to speak with considerable caution, inasmuch as the Sub-family contains none but fossil species, and they are for the most part only found in the older calcareous rocks. So far as can be made out, the test, though more or less distinctly arenaceous, contains a much larger proportion of calcareous cement than is noticed in either of the Sub-families previously described; and a certain limited number of species appear to have perforated walls. The shell is generally thin, but in rare instances the inner surface is more or less cancellated.

In the Sub-family LOFTUSINÆ the test is characterised by its great thickness and its cancellated structure. Of the three genera which it includes, two are known only by fossil specimens, and so far as they are concerned the chemical composition of the living tests cannot be stated with certainty; the third, *Cyclammina*, is constructed of fine siliceous sand, cemented by means of a compound containing a large proportion of peroxide of iron. But the conspicuous feature of the entire Sub-family is not so much the chemical nature of the investment as its structural peculiarity, in that it exemplifies the fullest development of what is known as the labyrinthic or cancellated variety of shell-structure.[1]

[1] I am well aware, of course, that the Rhizopodal nature of *Parkeria* and even of *Loftusia* has been called in question; but have seen no evidence which, so far as I can judge, contravenes in any way the general accuracy of the observations and conclusions set forth in the original description of these genera. With regard to *Loftusia*, the minute structure is that of *Cyclammina*, the contour that of *Alveolina*, and I am persuaded that but for its comparatively large size, its foraminiferal character would never have been demurred to. Prof. P. Martin Duncan's researches on the *Syringosphæridæ*, a group of fossils closely allied to *Parkeria*, tend to confirm the views originally expressed as to its zoological position, and the occurrence of a porcellanous isomorph, in *Keramosphæra*, has an interesting bearing in the same direction. Finally, since the present sheets have been in the hands of the printer, the discovery in the living condition of *Syringammina*, a well-characterised Rhizopod, with arenaceous test similar in form and dimensions to *Parkeria*, and exhibiting structural features in many ways analogous, helps to remove any lingering doubt on the subject.

It follows, therefore, that whilst the LITUOLIDÆ generally are characterised by the composite nature of their tests, the precise structure differs sufficiently to furnish distinctive characters for the four Sub-families under which they have been arranged,—the rough investment being the salient feature of the LITUOLINÆ, the smoothly-finished test that of the TROCHAMMININÆ, the thick cancellated walls the peculiarity of the LOFTUSINÆ, and the almost exclusively calcareous shell that of the ENDOTHYRINÆ.

In morphological characters the four Sub-families run in parallel rather than consecutive lines, and all the more important forms are, to a greater or less degree, isomorphous with the prominent types of the hyaline and porcellanous series of Foraminifera.

Thus amongst the LITUOLINÆ, the flask-shaped and linear species included in the genus *Reophax* correspond in external form with the perforate genera *Lagena* and *Nodosaria;* the partially or completely spiral forms comprised under the term *Haplophragmium* furnish arenaceous parallels, when symmetrical, to *Cristellaria* and *Nonionina,* when inequilateral, to *Rotalia* and *Globigerina;* the outspread, sandy, planospiral type, *Coskinolina,* resembles in like manner certain modifications of the porcellanous genus *Peneroplis;* whilst amongst the varieties of *Placopsilina* may be found isomorphs of the adherent *Truncatulinæ.* In *Haplostiche, Lituola,* and *Bdelloidina* the same forms are repeated, but with labyrinthic chambers.

The morphological sequence of the TROCHAMININÆ is very similar. The genus *Hormosina* furnishes smooth arenaceous isomorphs of *Lagena* and *Nodosaria,* of which *Webbina* is the adherent modification. The spiral *Trochamminæ* and the aberrant type *Carterina* follow the same plan of growth as *Nonionina* and *Rotalia; Thurammina* resembles *Orbulina;* and the porcellanous genera *Cornuspira* and *Miliolina* find collateral representations in the genus *Ammodiscus.* There appears to be no nearer parallel to *Hippocrepina* than the genus *Lagena;* unless indeed the slight transverse constrictions of the test are the remains of abortive septation, marking it as an arrested modification of a polythalamous form.

In the Sub-family ENDOTHYRINÆ, the series is less complete and the relations of the individual types are more obscure. Nevertheless, the genus *Nodosinella,* and in a less degree *Polyphragma,* bear some morphological resemblance to *Nodosaria;* and in *Involutina* there is a near approach to the typical conformation of *Cornuspira* and *Spirillina.* The various species of *Endothyra* and *Bradyina* furnish parallels to *Nonionina* and even to *Rotalia;* and last of all *Stacheia* presents varieties approximating structurally to *Polytrema* and *Gypsina.*

Of the three generic types assigned to the LOFTUSINÆ, *Cyclammina* finds a parallel in the porcellanous *Peneroplis* or in the hyaline *Cristellaria, Nonionina,* and *Nummulites;* and *Loftusia* in the porcellanous *Alveolina* or the hyaline *Fusulina;* whilst *Parkeria* has a porcellanous representative in *Keramosphæra.*

Sub-family 1. Lituolinæ.

Reophax, Montfort.

Reophax, Montfort [1808], Brady, Norman, Siddall, Bütschli, Carpenter.
Orthoceras, Defrance [1824].
Nodosaria, pars, d'Orbigny [1826], Terquem.
Proteonina, pars, Williamson [1858].
Lituola, pars, Parker and Jones [1860], Brady, M. Sars, G. M. Dawson, Robertson, Winther, &c.
Haplostiche, Schwager [1865].
Dentalina, pars, Terquem [1870].

Test free, coarsely arenaceous; composed either of a single inflated chamber, or of a number of chambers joined end to end in a straight, curved, or crooked (never spiral) linear series. Chamber-cavities undivided; aperture simple, terminal.

The term *Reophax* appears to be the earliest generic designation applied to any member of this group, and it has therefore been adopted to include all the free, non-spiral, and non-labyrinthic *Lituolæ*. It is a term of convenience only, and of about the same value in relation to *Haplophragmium*, as *Nodosaria* to *Cristellaria* amongst the hyaline types.

The genus *Reophax* is cosmopolitan, and its bathymetrical range extends from almost the deepest portions of the sea-bottom yet explored to the shallow water of the Laminarian zone. Its geological history is practically that of a single species, *Reophax scorpiurus*, which goes back as far, at least, as the Jurassic period.

Reophax difflugiformis, H. B. Brady (Pl. XXX. figs. 1–5).

Reophax difflugiformis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. N. S., p. 51, pl. iv. fig. 3 *a.b.*
„ „ Id., 1882, Proc. Roy. Soc. Edin., vol. xi. p. 715.

Test free; consisting of a single, elongate, oval or pyriform chamber, with or without a produced tubular neck; walls arenaceous, very variable in texture; aperture simple. Length, $\frac{1}{70}$th to $\frac{1}{40}$th inch (0·36 to 0·63 mm.).

Had this little organism been found in fresh or brackish water, or even in shore-pools it would, without doubt, have been assigned to the *Difflugiæ;* and it is perhaps an assumption rather than an ascertained fact that Rhizopoda with lobose pseudopodia have no home in the deep sea. Nevertheless, as the test bears the same sort of relation to the moniliform *Lituolæ* as that of *Lagena* does to the *Nodosariæ*, there is a natural place for it in the Reticularian series.

There seemed a possibility at first that the species might turn out to be only the primordial chamber of *Reophax scorpiurus*, but as it has since been found in considerable abundance in at least one area at which the latter form does not occur, it is evident that it holds an independent position.

The structure of the test varies with the locality and the nature of the sea-bottom. The walls are often composed of fine siliceous grains very neatly joined together, as in figures 1, 2, 3; sometimes they are beset with projecting sponge-spicules, as in figure 4; but more frequently, especially in northern habitats where the species is most plentiful, the test is constructed of coarse sand and has a very rough exterior, as shown in figure 5.

I have notes of the occurrence of *Reophax difflugiformis* at about forty localities. It was found in thirteen out of sixteen soundings obtained on the shores of Franz-Josef Land and Novaya-Zemlya, in latitudes extending to nearly 80° north, at depths of from 55 fathoms to 219 fathoms. It is common in the Faröe Channel, 530 to 555 fathoms, and has been taken at four other points in the North Atlantic, ranging from 420 to 2435 fathoms; it also occurs in shallow water in Dublin Bay. The following localities complete the record of its distribution:—four Stations in the South Atlantic, 1035 to 2200 fathoms; off Kerguelen Island, 120 fathoms; the Southern Ocean, south of Australia, 2600 fathoms; seven Stations in the South Pacific, 58 to 2425 fathoms; and three in the North Pacific, 2300 to 3950 fathoms.

My first acquaintance with the species was from a fossil specimen in Mr. Robertson's collection, obtained many years ago from the Post-tertiary College Clay of Cumbrae; but I cannot speak with certainty of its occurrence elsewhere in the fossil state. At the same time, judging from the extremely variable contour and texture of recent specimens, I have very little doubt that the Cretaceous forms described by Berthelin under the names *Haplophragmium scruposum* and *Haplophragmium lagenarium*,[1] and possibly also some reputed Mesozoic *Lagenæ*, in reality belong to this species.

Reophax ampullacea, H. B. Brady (Pl. XXX. fig. 6, *a.b.*).

Reophax ampullacea, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 49.

Test monothalamous, compressed; broad and rounded at the base, tapering towards the distal end; exterior rough. Length, $\frac{1}{30}$th inch (0·84 mm.).

This is a somewhat large flattened variety, bearing the same sort of relation to *Reophax difflugiformis* that *Lagena marginata* bears to *Lagena globosa*.

It has only been met with at one locality,—off Christmas Harbour, Kerguelen Islands, 120 fathoms.

Reophax fusiformis, Williamson, sp. (Pl. XXX. figs. 7–11).

Proteonina fusiformis, Williamson, 1858, Rec. For. Gt. Br., p. 1, pl. i. fig. 1.
Lituola nautiloidea, var. *scorpiurus*, Parker and Jones, 1862, Introd. Foram., App., p. 309.
Lituola fusiformis, Wright, 1877, Proc. Belfast Nat. Field Club, 1866–7, Appendix,—Table.
Reophax fusiformis, Siddall, 1879, Catal. Brit. Rec. Foram., p. 4.

[1] *Mém. Soc. géol. France*, sér. 3, mém. 5, p. 21, pl. i. figs. 1, 2.

Test free, asymmetrical; oblong, fusiform, or subcylindrical; cavity either entire or spuriously divided by one or more incomplete transverse septa. Walls coarsely arenaceous, rough externally; aperture simple, terminal. Length, $\frac{1}{40}$th inch (0·63 mm.) or more.

This is a starved shallow-water variety of *Reophax scorpiurus*. The test is often, as described by Prof. Williamson, without internal septa, but more commonly is spuriously segmented near the inferior extremity, and consists in fact of a small chamber surmounted by one of much larger size. It can scarcely be distinguished except by comparative characters from poor specimens of the typical species.

Reophax fusiformis is of somewhat restricted distribution. It is found in the Arctic Ocean as far north as lat. 78° 40′ N. (Robertson, Brady), and at various points on our own shores, especially on the western coast of Scotland, at depths seldom exceeding 40 or 50 fathoms. In the North Atlantic, west of Ireland, it has been met with at two of the "Porcupine" Stations, in much deeper water, 630 fathoms and 1443 fathoms respectively. The species only occurs at one Challenger Station, No. 209, Philippine Islands, 95 fathoms.

Reophax scorpiurus, Montfort (Pl. XXX. figs. 12–17).

"Orthoceras" ?, Soldani, 1795, Testaceographia, vol. i. pt. 3, p. 239, pl. clxii. fig. *K*.
Reophax scorpiurus, Montfort. 1808, Conchyl. Systém., vol. i. p. 330, 83e genre.
Nodosaria (*Dentalina*) *scorpionus*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 255, No. 40.
Lituola scorpiurus, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 467, pl. xlviii. fig. 5.
„ *nautiloidea*, var. *scorpiurus*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 407, pl. xv. fig. 48, *a. b.*
Nodosaria agglutinans, Terquem, 1870, Mém. Acad. Imp. Metz, 1869–70, p. 252, pl. xxix. fig. 18.
Lituola scorpiurus, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 159, pl. ix. fig. 29.
Reophax scorpiurus, Siddall, 1879, Catal. Brit. Rec. For., p. 4.
„ *helvetica*, Haeusler, 1883, Quart. Journ. Geol. Soc., vol. xxxix. p. 27, pl. ii. figs. 8–10.

Test free; consisting of several (usually 4 to 6) somewhat inflated segments, of irregular size and shape, usually increasing in size from the first to the last, joined together in a more or less curved or crooked line. Texture coarsely arenaceous, surface rough. Length very variable, $\frac{1}{50}$th to $\frac{1}{6}$th inch (0·5 to 4 mm.).

The general contour and minuter characters of the test of *Reophax scorpiurus* depend in great measure upon the locality in which it is found. On sandy bottoms it generally occurs in the rough condition represented in fig. 12; whilst in pure Globigerina ooze the siliceous grains are replaced by the empty shells of the smaller Foraminifera, which, cemented together, form a test such as that shown in fig. 13. In localities

where sponges are plentiful, their spicules, broken or entire, are often used in place of sand, as in fig. 14; and amongst the coral-reefs of the tropics the rough calcareous débris is employed in the same way, figs. 15, 16. The minute structure of a test of the latter description, constructed of very large grains, chiefly calcareous, is exemplified in the sectional drawing, fig. 17.

It is obvious that an organism so dependent on external conditions must assume a great diversity of external characters. Two of the more regular varieties, which in addition to their symmetrical contour and neater build, present some peculiarities of distribution, have been described separately as *Reophax pilulifera* and *Reophax dentaliniformis* respectively.

A very interesting modification of the type, somewhat allied to these regular forms, has been described elsewhere under the name *Reophax arctica*.[1] The test in this case is straight, regularly built and somewhat tapering; but instead of being cylindrical in section, is compressed and bilateral, like *Lingulina*. It is an exceedingly minute species, and has only been found hitherto on the shores of Novaya Zemlya and Franz-Josef Land.

Reophax scorpiurus is one of the commonest of cosmopolitan species. It is abundant in the Arctic Ocean to almost the extreme limits of our geographical knowledge, and occurs plentifully in all the great ocean-basins, its area of distribution extending at least as far south as Heard Island, about lat. 53° S. The bathymetrical range of the species is on a corresponding scale. In the tropics it is found at depths commencing with 3 or 4 fathoms, and in colder areas on bottoms as shallow as 30 or 40 fathoms; and from depths such as these down to 3950 fathoms, it is met with at every stage.

There can be no doubt that the specimens figured by Terquem from the Oolite of Fontoy, Moselle (*Nodosaria agglutinans*), and those described by Haeusler from the Jurassic formations of Switzerland (*Reophax helvetica*) belong to the present species; it is also one of the forms enumerated by Messrs. Crosskey and Robertson in their list of Foraminifera from the Post-tertiary beds of Norway. I find no other satisfactory record of its occurrence in the fossil state.

Reophax pilulifera, n. sp. (Pl. XXX. figs. 18–20).

Test straight or curved; composed of few (3 to 5) segments. Segments spherical, each much larger than its predecessor. Walls composed of coarse sand-grains, but compactly built and presenting a nearly smooth exterior. Aperture simple, central, often situated in a mammillate protuberance. Length, $\frac{1}{10}$th inch (2·5 mm.).

This is little more than a local variety of *Reophax scorpiurus*, characterised by its spherical segments and comparatively regular contour.

[1] *Denkschr. d. k. Akad. Wiss. Wien*, 1881, vol. xliii. p. 99, pl. ii. fig. 2, *a.b.*

It is a somewhat rare form, and appears to be peculiar to deep water. Specimens occur at five "Porcupine" Stations in the North Atlantic, west and south of Ireland, 800 to 2435 fathoms; at one Challenger Station off the west coast of Africa, 1750 fathoms; at two in the South Atlantic, 1900 fathoms and 2350 fathoms respectively; at four in the South Pacific, 400 to 1425 fathoms; and at one in the North Pacific, 2350 fathoms.

Reophax dentaliniformis, H. B. Brady (Pl. XXX. figs. 21, 22).

Reophax dentaliniformis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 49.

Test long, slender, cylindrical, tapering; straight or more or less bent; composed of several (usually 5 or 6) elongate, slightly ventricose segments. Texture somewhat coarsely arenaceous, but neatly cemented and not very rough externally. Aperture produced, often forming a short wide tubular neck. Length, about $\frac{1}{14}$th inch (1·85 mm.).

Under this name the *Dentalina*-like modifications of *Reophax scorpiurus* have been grouped together. Such specimens are generally very easily distinguished from the type by their slender proportions and regular contour, as well as by the lighter colour of the test.

Reophax dentaliniformis is widely distributed, though it is by no means a common variety. It occurs in all the great oceans, but is very rare in the South Atlantic. Like *Reophax pilulifera*, its home is on deep sea-bottoms, and out of twenty-one Stations at which its presence has been noted, only four have a depth of less than 1000 fathoms, whilst seven are above 2000, and two above 3000 fathoms.

Reophax bacillaris, Brady (Pl. XXX. figs. 23, 24).

Reophax bacillaris, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 49.

Test long, cylindrical, regularly tapering, somewhat bent; composed of a large number of short segments. Earlier segments cylindrical, with flush sutures not distinguishable on the exterior; later ones subspherical. Aperture central, simple. Colour dark grey. Length, about $\frac{1}{6}$th inch (4·2 mm.) more or less.

This is a rare species, and may be distinguished by its numerous segments and the dark grey hue of the test. It was obtained both by Dr. Carpenter and the Rev. A. M. Norman from one of the "Valorous" soundings in the North Atlantic,—No. 8, lat. 59° 10′ N., long. 50° 25′; W.; depth, 1750 fathoms; and I am indebted to them for the specimens from which the drawings, figs. 23, 24, have been taken. Some broken tests belonging to the same species were found in one of the "Porcupine" dredgings, south of Rockall Bank, 420 fathoms, and at one of the Challenger Stations on the north coast of Papua, 1070 fathoms; but all of them inferior to the foregoing in point of size and distinctiveness.

Reophax nodulosa, H. B. Brady (Pl. XXXI. figs. 1–9).

Reophax nodulosa, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 52, pl. iv. figs. 7, 8.

Test long, slender, tapering, straight or arcuate; consisting of several (usually less than 12) segments, joined regularly end to end, and more or less embracing. Segments oblong, rounded, oval, or pyriform, somewhat inflated; primordial segment sometimes relatively large, the remainder increasing in size towards the distal end of the test. Exterior rough in large specimens, comparatively smooth in smaller ones; interior neatly finished. Size very variable; length, from $\frac{1}{40}$th inch to 1 inch (0·5 to 25 mm.) or more.

The series of figures heading Pl. XXXI. sufficiently demonstrates the great variety of size and contour assumed by specimens of the present species; nevertheless in all important characters its members agree exceedingly well. Between straight and arcuate tests no distinguishing line can be drawn. Some individuals are stout and few-chambered, and each fresh segment is considerably larger than the previous one; whilst others with relatively small initial segments, have many chambers, are of slender contour, and taper very gradually; some specimens are rough and coarse-textured, whilst others are nearly smooth externally, the sand-grains being almost completely incorporated by the excess of cement. In size the variation is correspondingly wide; minute specimens measure but half a millimetre, whilst there are others that attain fifty times that length, and are amongst the very largest of recent arenaceous Foraminifera.

The chemical composition of the test has been investigated with some care; and it has been found that the larger specimens are not really disintegrated by treatment with nitric acid, but retain their general form unchanged. This is the case even when tolerably strong acid is used, and the digestion continued long enough to ensure the complete removal of both the calcareous and ferruginous constituents of the cement. A specimen which has been treated in this way is represented in fig. 2; and a comparison with the previous figure will show that the only conspicuous alteration in appearance is that the normal brown hue has given place to a dirty grey. The walls are porous and fragile, but the test still possesses sufficient firmness and cohesion to bear careful handling. Any cement which still remains must be siliceous, either in the form of uncombined silica or of some metallic silicate, but the entire quantity is probably comparatively small.

The geographical distribution of *Reophax nodulosa* is very wide. It occurs frequently amongst arctic soundings taken on the shores of Franz-Josef Land at depths of 89 to 145 fathoms, but the specimens are small; and there are one or two starved examples in Mr. Robertson's collection, from shallow-water on the west coast of Scotland. Elsewhere it has only been met with in deep water. In the North Atlantic, mid-ocean, it has been found at three Stations, ranging from 1070 to 3150 fathoms; and in the South Atlantic at three Stations, from 1900 to 2800 fathoms. In the Southern Ocean it is tolerably common;

and the immense specimens which have been referred to were obtained at Stations 155 and 156, very near the Antarctic Ice-barrier, depth 1300 fathoms and 1975 fathoms respectively. In the Pacific Ocean it is also plentiful, its presence having been noted at six Stations south of the equator, 1070 to 2600 fathoms, and at seven north of the equator, 1850 to 2950 fathoms.

Reophax guttifera, H. B. Brady (Pl. XXXI. figs. 10–15).

Reophax guttifera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 49.
„ „ Id. 1882, Proc. Roy. Soc. Edin., vol. xi. p. 711.

Test elongate, nearly straight; composed of several (3 to 8) inflated segments. Segments variable in contour, typically pyriform; broadest near the base, and tapering to a narrow stoloniferous tube at the point of union with the succeeding chamber. In small specimens the base of the segments is often truncate or even somewhat concave; in larger examples the chambers are less regular in outline and the connecting stolons are wider. Texture coarsely arenaceous; exterior rough; colour yellowish-brown. Length, seldom exceeding $\frac{1}{16}$th inch (1·6 mm.).

The series of drawings (Pl. XXXI. figs. 10–15) conveys more effectively than many words a just idea of the range of form exhibited by this species. The smaller specimens are more easily recognised than those of larger size; yet even the largest and most irregular preserve to some extent the normal pyriform contour of the segments, and their comparatively thin stoloniferous connections. These characters, together with the nearly straight test, serve to distinguish the longer individuals from such forms as *Reophax adunca*, which they otherwise somewhat resemble.

Reophax guttifera is an exceedingly rare species. The figured specimens are all from a single locality, Station 323, South Atlantic, east of Buenos Ayres, 1900 fathoms. It occurs also in the cold area of the Faröe Channel, 540 fathoms; and a single somewhat doubtful example was met with at Station 85, off Palma, Canaries, 1125 fathoms.

Reophax spiculifera, H. B. Brady (Pl. XXXI. figs. 16, 17).

Reophax spiculifera, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 54, pl. iv. figs. 10, 11.

Test elongate, straight or arcuate; consisting of a few (3 to 6) cylindrical segments. Shell-wall composed of siliceous spicula arranged side by side, and firmly cemented together. Spicula often protruding more or less from the base of the segments. Length, $\frac{1}{25}$th inch (1·0 mm.).

This is one of the many species of Foraminifera that give evidence of considerable selective power in respect of the material employed for the construction of their tests.

That it is selective power, and does not depend upon the absence of the angular sand-grains, which are the ordinary constituent of the composite shells of the *Lituolæ*, is demonstrated by the fact that other species occur in the same soundings in their normal sandy condition; and that the orderly arrangement of the spicula side by side, and the neat and compact masonry of the walls cannot be entirely accidental, becomes additionally evident when it is contrasted with the indiscriminate use of sponge-spicula amongst sand-grains and various other extraneous bodies, seen in the tests of many of the larger Arenacea, or even in specimens of the closely allied *Reophax difflugiformis* or *Reophax scorpiurus* obtained from localities where such objects abound.

The best specimens of *Reophax spiculifera* hitherto obtained are from two Stations off Kandavu, Fiji Islands, 255 fathoms and 610 fathoms respectively, and from a sounding off Tahiti, Society Islands, 620 fathoms.

Reophax distans, H. B. Brady (Pl. XXXI. figs. 18–22).

Reophax distans, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 50.

Test elongate, straight or curved; composed of numerous segments connected end to end by slender stoloniferous tubes. Segments large, distinct, fusiform; tapering nearly equally at the two ends. Never found entire; length of specimens with three chambers, nearly $\frac{1}{5}$th inch (5 mm.).

Reophax distans may be regarded as the arenaceous isomorph of *Nodosaria pyrula*, but it is even more fragile than the latter species, owing to the tenuity of the stoloniferous tubes in proportion to the bulk of the chambers they connect. Hence individuals with as many as three segments are seldom met with, and even these have not the appearance of complete specimens.

The species is very rare except in the Pacific, and its distribution is almost exclusively confined to deep water. It occurs in the Faröe Channel, 355 fathoms; and at one other Station in the North Atlantic, off the African coast, 1750 fathoms; at one Station in the South Atlantic, east of Buenos Ayres, 1900 fathoms; at two in the Southern Ocean—between the Cape of Good Hope and the Kerguelen Islands, 1570 fathoms, and south of Australia, 2600 fathoms; at four Stations in the South Pacific, from 1070 to 2160 fathoms; and at four in the North Pacific, 2050 to 2775 fathoms.

Reophax adunca, H. B. Brady (Pl. XXXI. figs. 23–26).

Reophax adunca, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 715.

Test moniliform; consisting of a crooked line of inflated segments of somewhat irregular size but of nearly equal diameter. External constrictions between the segments

comparatively slight ; walls thin, rough externally. Length indefinite, specimens seldom found with either end entire ; sometimes $\frac{1}{12}$th inch (2 mm.) or more.

Reophax adunca, as ordinarily met with, consists of a moniliform line of slightly inflated segments so nearly alike that it is difficult to say which is the growing end of the test ; indeed it is quite possible, for any evidence that exists to the contrary, that it may put on fresh segments at either extremity. It resembles to some degree both *Reophax guttifera* and *Hormosina monile*, but is less regular in outline and has thicker stolons than the former ; and its want of regularity, comparatively small size, and rough exterior distinguish it from the latter species.

Reophax adunca is found as far north as the Faröe Channel, 540 fathoms ; and at about the same latitude in mid-Atlantic, 1750 fathoms ; south of Rockall Bank, 1215 fathoms ; and off the Canaries, 1125 fathoms. It occurs at three Stations in the South Atlantic, 675 to 2200 fathoms ; at two in the Southern Ocean,—between the Cape of Good Hope and Kerguelen Islands, 1570 fathoms, and south of Australia, 2600 fathoms ; at two points in the South Pacific, 1375 and 1425 fathoms respectively, and at three in the North Pacific, 2050 to 2900 fathoms.

Reophax membranacea, H. B. Brady (Pl. XXXII. figs. 1–4).

Reophax membranacea, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 53, pl. iv. fig. 9.

Test long, slender, tapering, arcuate or nearly straight ; consisting of several (5 to 10) subcylindrical or elliptical segments joined end to end. Walls thin, chitinous, beset with minute adherent sand-grains ; often transversely wrinkled. Length, $\frac{1}{18}$th inch (1·4 mm.).

In one or two deep soundings from very muddy bottoms minute moniliform *Lituolæ* have been found, possessing a delicate investment of light brown tint and nearly transparent. The test is only partially soluble in weak acids, and it appears to consist of calcareous and chitinous matter, with sometimes a few very minute, adherent or embedded siliceous sand-grains. The mineral constituents exist in sufficient quantity to effervesce slightly with an acid, and to render the test brittle rather than flexible after it is dried ; but the surface is wrinkled transversely, in a manner strongly suggestive of a membrane covering a soft or plastic mass. Referring to the drawings of the species in Pl. XXXII.—figs. 1 and 2 represent specimens in their natural condition, mounted dry ; fig. 4 a specimen mounted in Canada balsam, viewed by transmitted light ; and fig. 3 a test that has been treated with dilute acid, mounted in balsam. Unfortunately the species is

very rare and the specimens exceedingly small, so that material does not exist for more detailed investigation as to the chemical nature of the test; nor is sufficient known of the condition of the sea-bottom in these cases, to account for any deviation from the normal type of structure.

The best examples of *Reophax membranacea* hitherto obtained are from the South Atlantic, off the coast of South America, in about the same latitude as Buenos Ayres, 1900 fathoms; but it occurs also in the deep area of the North Pacific, Station 238, depth 3950 fathoms.

Reophax sabulosa, H. B. Brady (Pl. XXXII. figs. 5, 6).

Reophax rudis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 49.
„ „ Carpenter, 1881, "The Microscope," 6th ed., p. 563, figs. *a.b.*
„ *sabulosa*, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 715.

Test elongate, cylindrical, slightly tapering; sides even and unconstricted, extremities rounded. Walls thick, composed of rather fine grey sand only partially cemented, and showing no external marks of segmentation. The longitudinal section reveals about six segments, each tapering at the summit to a stoloniferous tube, the mouth of which, as well as the external aperture of the test, is stained reddish-brown. Length, $\frac{4}{10}$th inch (10 mm.) or more.

This species was originally described in one of the preliminary notices of Challenger Foraminifera under the name *Reophax rudis*, but it was subsequently found that the same specific term had been previously employed by Costa for another variety of the type, and the present name was therefore substituted for it.

Reophax sabulosa furnishes some of the largest examples of the genus, the only variety attaining superior dimensions being *Reophax nodulosa*. Its thick and somewhat loosely constructed walls bear more resemblance to the investment of *Astrorhiza arenaria* than to the firmly agglutinated tests of its immediate congeners; nevertheless its well-marked segmentation, and the manifest relationship of the species to such forms as *Reophax cylindrica*, the characters of which are more in harmony with the rest of the group, are sufficient evidence of its Lituoline affinity. The brown colouring of the septal apertures is a not uncommon feature of loose sandy tests deficient in cement, and appears to be due to an organic pigment.

Reophax sabulosa has only been found in the cold area of the Faröe Channel, at depths of 530 and 540 fathoms. The original specimens, two of which form the subject of the figures in Pl. XXXII., were obtained by Dr. Carpenter during the cruise of the "Lightning" in 1868, and it has been taken more recently near the same spot on the cruise of the "Knight Errant."

Reophax cylindrica, n. sp. (Pl. XXXII. figs. 7–9).

Test long, straight, cylindrical, of nearly even diameter throughout or regularly tapering; broadest near the oral end; inferior extremity round, superior tapering, truncate, bearing a simple circular aperture. Exterior smoothly finished, without sutural constrictions or other superficial marks of segmentation. The longitudinal section showing a series of six to eight short cylindrical chambers, separated by thick, flat septal plates. Length, about $\frac{1}{7}$th inch (3·6 mm.).

Except a single broken test, this species has not been found in either the Challenger or "Porcupine" gatherings, and I am indebted to the Rev. A. M. Norman for the specimens represented in figs. 7 and 8.

Reophax cylindrica may be readily identified amongst its congeners by its slender and regularly cylindrical contour, and the absence of external indications of its interior structure, except such as depend on slight differences in colour. It is of smaller dimensions than *Reophax sabulosa*, the species it otherwise most nearly resembles, and though the walls are of similar texture, they are thinner and more compactly built. The interior of the test is even more characteristic, for, whilst the successive chambers of the latter species are embracing and taper towards the distal ends, the septa of *Reophax cylindrica* take the form of nearly flat transverse plates, as shown in the sectional drawing, fig. 9.

Mr. Norman's specimens were obtained from one of the "Valorous" soundings in the North Atlantic, lat. 59° 10′ N., long. 50° 25′ W.; depth, 1750 fathoms. The Challenger fragment was found at Station 144, between the Cape of Good Hope and the Kerguelen Islands, 1570 fathoms.

Reophax findens, Parker, sp. (Pl. XXXII. figs. 10, 11).

Lituola findens, Parker, 1870 (in Dawson's paper) Canad. Nat., vol. v., N. S., p. 177; p. 180, fig. 1.
„ „ Siddall, 1878, Proc. Chester Soc. Nat. Sci., pt. ii. p. 47.
Reophax findens, Id. 1879, Catal. Brit. Rec. For., p. 4.

Test elongate; composed of a short line of inflated segments, dividing at one end into two or more branches, each consisting of a similar series of chambers of smaller size. General aperture simple, situated at the broad end of the test; in immature specimens orifices frequently exist at the extremities of the branches also. Texture coarsely arenaceous; exterior rough. Length, $\frac{1}{20}$th inch (1·26 mm.).

Reophax findens is a somewhat anomalous species; and, though it appears by name in two or three published memoirs, and has been figured by Dr. G. M. Dawson in his paper on Foraminifera from the Gulf and River St. Lawrence, it has not hitherto been described. The test consists of a line of from two to five Lituoline chambers joined

end to end, and supplemented at the narrower extremity by two or rarely three branches. The branches, which are of little more than half the diameter of the larger segments, consist individually, when complete, of about three subcylindrical or oval chambers. The principal aperture is at the broader end, and the branched condition of the test can only be accounted for on the supposition that the growing chambers have inferior as well as superior orifices. In some specimens I have found that this is actually the case, but in the complete test the terminal segments of the branches are closed and rounded. In one example the large end chamber has two distinct apertures, as though the test were ready to bifurcate at the superior as well as at the inferior end.

For the figured specimens of *Reophax findens*, I am indebted to my friend Dr. G. M. Dawson of Montreal. They are from the original locality, Gaspé Bay, Gulf of St. Lawrence, depth 15 to 20 fathoms. Mr. J. D. Siddall has good examples from the estuary of the Dee; but beyond these I know of no other authenticated locality for the species.

Haplophragmium, Reuss.

Spirolinites, Northampton [1838], Mantell.
Spirolina, pars, Roemer [1840], Reuss, d'Orbigny, Karrer.
Orbignyna, Hagenow [1842].
Placopsilina, Reuss [1854], Parker and Jones, Morris and Quekett.
Nonionina, pars, Bornemann [1855], Schultze, Williamson, Parfitt, Terquem.
Proteonina, pars, Williamson [1858], Terquem.
Lituola, pars, Parker and Jones [1860], Carpenter, Brady, M. Sars, Whiteaves, G. M. Dawson, Winther, Schulze, Berthelin, Terrigi, Robertson, &c.
Haplophragmium, Reuss [1860], Stache, Schwager, Gümbel, Hantken, Terquem, Brady, Wright, Siddall, &c.
Flabellina pars, Terquem [1870].
Endothyra, pars, Möller [1879].
Raphidohelix, Moebius [1880].

Test free or rarely adherent, convoluted; consisting of numerous segments arranged in a nautiloid, Rotaliform, or trochoid spire, or planospiral at the commencement and subsequently combined in a straight or curved linear series. Aperture simple or divided. Walls coarsely arenaceous, rough externally; chamber-cavities non-labyrinthic.

The genus *Haplophragmium*, as instituted by Reuss, is distinguished from *Lituola* (proper) by its non-labyrinthic chambers. It consists for the most part of sandy isomorphs of the *Cristellariæ* and *Nonioninæ*, but embraces in addition a number of inequilaterally spiral forms, which assume to a greater or less extent the Rotalian plan of growth. It has consequently a similar morphological range to *Trochammina* (proper), but the test of *Trochammina* is smooth and finely-cemented, whilst that of *Haplophragmium* is rough and coarsely arenaceous.

The earliest appearance of the type, geologically speaking, is in the Carboniferous epoch, and from that remote era down to recent times it is found in microzoic strata of almost every age.

Haplophragmium agglutinans, d'Orbigny, sp. (Pl. XXXII. figs. 19–26).

Spirolina agglutinans, d'Orbigny, 1846, For. Foss. Vien., p. 137, pl. vii. figs. 10–12.
„ *simplex*, Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 232, pl. ii. fig. 30.
Haplophragmium rectum, Brady, 1876, Monogr. Carb. and Perm. Foram., p. 66, pl. viii. figs. 8, 9.

Test elongate, crosier-shaped; planospiral at the commencement, subsequently linear. Spiral portion relatively small, consisting of little more than one visible convolution; compressed, excavated at the umbilici; peripheral edge rounded. Linear portion cylindrical, slightly increasing in size towards the distal end, seldom composed of more than six or seven segments; septation often obscure in large specimens. Aperture simple, central, terminal. Length, $\frac{1}{100}$th to $\frac{1}{10}$th inch (0·25 to 2·5 mm.).

The general features of *Haplophragmium agglutinans* are adequately illustrated by the series of figures given in Pl. XXXII. The drawings, which are all done to the same scale, show also the great diversity that exists in the size of the specimens. The characters of the species are nevertheless tolerably uniform in other respects, and specimens measuring $\frac{1}{100}$th inch have about the same number of segments as those ten times that length, and are very similar in general contour. The chambers are generally subcylindrical, sometimes slightly inflated; when the walls are thin, the sutural lines are distinct (fig. 21, &c.), but when the test is thick (figs. 19, 24), or very rough externally (fig. 20), the segmentation can scarcely be traced on the exterior.

The figures of crosier-shaped *Lituolinæ* given by the earlier authors are for the most part exceedingly obscure, and the various forms are associated with the long varieties of *Peneroplis*, under the generic term *Spirolina*. They are usually more or less irregular, and show signs of labyrinthic structure.

There can be little doubt that the *Haplophragmium rectum* of the Carboniferous Monograph (*loc. cit.*) belongs to the present species. It was named before the extent of variation in the group, of which d'Orbigny's figure is the central type, was fully recognised.

Haplophragmium agglutinans is found living in every part of the world, and it has a wide bathymetrical range, though comparatively rare in shallow water. Small specimens have been obtained on our own shores, off the Isle of Wight (Millett) and in Dublin Bay (Wright). Its distribution list includes nine Stations in the North Atlantic, the depths of which vary from 530 to 2750 fathoms, the furthest northern limit being

the entrance to Davis Strait; two Stations in the South Atlantic, 2200 and 2900 fathoms respectively; seven in the South Pacific, from 2 fathoms to 2600 fathoms; and five in the North Pacific, from 7 fathoms to 3125 fathoms.

Its geological range is correspondingly extensive. It makes its appearance in the Lower Carboniferous rocks of Yorkshire, and occurs subsequently in the Upper Lias of Yorkshire (Tate); in the Lower Tertiary sands of Cassel in Germany (Reuss); and in the Miocene of Baden near Vienna (d'Orbigny).

Haplophragmium pseudospirale, Williamson, sp. (Pl. XXXIII. figs. 1–4).

Proteonina pseudospiralis, Williamson, 1858, Rec. For. Gt. Br., p. 2, pl. i. figs. 2, 3.
Lituola nautiloidea, "feeble form," Parker and Jones, 1862, Introd., Foram., Appendix, p. 309.
Haplophragmium pseudospirale, Siddall, 1879, Catal. Brit. Rec. For., p. 4.

"Test thin, compressed; at first exhibiting a tendency towards a spiral growth, but afterwards projected in a nearly straight line. Texture coarsely arenaceous and granular. Septal aperture oblong, at the extremity of the produced portion, but irregular and sometimes scarcely perceptible. Length, $\frac{1}{20}$th inch" (1·25 mm.).

To the foregoing description Prof. Williamson adds that he had "detected no trace of segmentation in this species, its interior consisting of an undivided cavity" and that "it obviously presents a rude and imperfectly developed example of a type of growth which assumes a completely symmetrical and concamerated condition in *Cristellaria* and its allies."

I have found it extremely difficult to determine, by means of sections or otherwise, the condition of the interior of the test, owing to the roughness of the inner as well as the outer surface. Williamson's conclusion is probably in the main correct; but in some cases the cavity appears to be divided in a rudimentary way, though the partitions are too irregular and imperfect to be regarded as septa.

Haplophragmium pseudospirale is not uncommon amongst the islands on the west coast of Scotland, at depths of 30 to 60 fathoms; it occurs in two of the "Porcupine" dredgings from the west of Ireland, 90 fathoms and 370 fathoms respectively; and the Rev. A. M. Norman has specimens from off Valentia, 110 fathoms.

Haplophragmium calcareum, n. sp. (Pl. XXXIII. figs. 5–12).

Test elongate compressed, the two surfaces nearly equally convex, peripheral edge blunt or angular; consisting of numerous segments, the earlier of which are arranged in a flat spire, the later ones in a straight or curved linear series; aperture simple, terminal. Of the spiral chambers, only the last convolution visible externally; those of the linear

series short and broad. Walls thick; segmentation complete; sutural lines generally well marked on the exterior. Length, $\frac{1}{7}$th inch (3·5 mm.).

Haplophragmium calcareum is probably the largest living representative of the genus, and almost equals in dimensions the finest Cretaceous species. The test is massively built, the walls thick and composed of coarse sand, often coral detritus or other calcareous matter, incorporated by means of an unusual proportion of calcareous cement.

The species differs from *Haplophragmium agglutinans* in its flattened contour, from *Haplophragmium pseudospiralis* in its distinct and regular segmentation, and from both in its large dimensions.

Under the name *Haplophragmium humboldti*,[1] Reuss has described a form which serves as a connecting link between *Haplophragmium agglutinans* and the present species. It resembles *Haplophragmium calcareum* in the compression of the earlier portion of the test, and *Haplophragmium agglutinans* in the nearly cylindrical contour of the later segments.

Haplophragmium calcareum has been found at six Challenger Stations, all of which, with a single exception, are within the tropics, namely :—off Culebra Island, West Indies, 390 fathoms; at two points off the coast of South America, south of Pernambuco, 675 fathoms and 350 fathoms respectively; off Kandavu, Fiji Islands, 210 fathoms; Torres Strait, 155 fathoms; and off Sydney, 410 fathoms.

Haplophragmium tenuimargo, H. B. Brady (Pl. XXXIII. figs. 13–16).

Haplophragmium tenuimargo, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 715.

Test elongate, crosier-shaped, much compressed; lateral edges thin and jagged. Spiral segments few and small; those of the linear series, about six in number, broad and slightly convex; septation obscure. Aperture simple, irregular in form, terminal. Texture coarse, surface extremely rough. Length, $\frac{1}{10}$th inch (2·5 mm.) or somewhat less.

In general appearance *Haplophragmium tenuimargo* is not unlike *Haplophragmium pseudospirale*, but the test exemplifies a marked advance in structure upon that of the latter species, the earlier portion being more evidently spiral, and the cavity definitely segmented, though externally the septation is indistinct. Its thin peripheral edge and jagged outline are very characteristic features.

The species has been obtained at six localities, very wide apart, the number of specimens in each case seldom exceeding two or three. The following is the list:—Faröe Channel, warm area, 530 fathoms; Challenger Station 5, south-west of the Canaries, 2740 fathoms; Station 323, east of Buenos Ayres, 1900 fathoms; Station 218, north of

[1] Originally as *Spirolina humboldti*, Reuss, 1851, *Zeitschr. d. deutsch. geol. Gesell.*, vol. iii. p. 65, pl. iii. figs. 17, 18, but subsequently as *Haplophragmium*.

Papua, 1070 fathoms; Station 168, east of New Zealand, 1100 fathoms; and Station 238, in the deepest portion of the North Pacific, 3950 fathoms.

Haplophragmium cassis, Parker, sp. (Pl. XXXIII. figs. 17–19).

Lituola cassis, Parker, 1870 (in Dawson's paper), Canad. Nat., N. S., vol. v. p. 177; p. 180, fig 3.

Test free, spiral at the commencement, bilaterally symmetrical or nearly so; elongate, arcuate, much compressed, outer margin thin and sharp. Initial (spiral) segments few and minute; those subsequently formed projected in a curved line, broad, subtriangular, and obliquely set. Aperture simple, situated at the distal extremity of the final segment. Walls thin, texture coarsely arenaceous, firmly cemented; colour brown. Length, $\frac{1}{18}$th inch (1·4 mm.).

Haplophragmium cassis is an arenaceous isomorph of *Cristellaria crepidula*, and except for the relatively large dimensions of the former and the different structure of the walls, the descriptive characters of the one species might, with but little impropriety, be employed for the other. It was one of a number of interesting Foraminifera which were first obtained by Dr. G. M. Dawson from the Gulf of St. Lawrence, and were figured in his memoir on the Rhizopod-fauna of that region, under names assigned to them by Prof. Parker.

Haplophragmium cassis is an extremely rare species, peculiar to the shallow water of northern seas. Its distribution list comprises only three localities:—Gaspé Bay, mouth of the river St. Lawrence, 16 fathoms (Dawson); Lievely Harbour, Disco, Greenland, 5 to 20 fathoms (Norman); and Deva Bay, Spitzbergen, lat. 77° 30′ N., depth 7 fathoms (Robertson).

For the figured specimens, which are from Gaspé Bay, I am indebted to my friend Dr. G. M. Dawson of Montreal.

Haplophragmium foliaceum, H. B. Brady (Pl. XXXIII. figs. 20–25).

Haplophragmium foliaceum, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 50.

Test crosier-shaped, complanate, very thin, flat on both sides; consisting of numerous segments, the earlier ones forming two to three convolutions of a flat spire, the later ones arranged in a broad, straight, linear series. Segmentation distinct; peripheral edge slightly constricted at the sutures; septal lines arched. Aperture simple, terminal. Length, $\frac{1}{20}$th inch (1·25 mm.).

Haplophragmium foliaceum is one of the most beautiful modifications of the Lituoline type. The test is of elegant crosier-like form, and so thin that, mounted in Canada balsam, its structure is fully displayed when viewed as a transparent object. Somewhat

coarse sand is used in its construction, but, as compared with other species of the same genus, the exterior is smooth and neatly finished.

The finest examples of *Haplophragmium foliaceum*, amongst them those figured in Pl. XXXIII., have been obtained from a black mud dredged at Station 323, in the South Atlantic, east of Buenos Ayres, 1900 fathoms, where it was tolerably abundant. The species has been met with at four other points, namely:—North Atlantic, mid-ocean, 2750 fathoms; south of Australia, 2600 fathoms; north of Papua, 1070 fathoms; and on the *Hyalonema*-ground, south of Japan, 345 fathoms, but the specimens from these localities are of poor dimensions and few in number.

Haplophragmium emaciatum, n. sp. (Pl. XXXIII. figs. 26–28).

Test free, discoidal, planospiral, more or less evolute; composed of about two convolutions. Lateral faces concave; peripheral edge thin, acute or somewhat rounded. Segments numerous, about seven in the outermost whorl, slightly inflated, the later ones somewhat embracing; septal lines depressed. Aperture a transverse arched slit at the base of the final segment, close to the margin of the previous convolution. Walls thin, rather coarsely arenaceous but firmly cemented; colour brown. Diameter, $\frac{1}{18}$th inch (1·4 mm.).

In the earlier stages of growth there is not much to distinguish *Haplophragmium emaciatum* from *Haplophragmium fontinense;* but in adult specimens the inflated and somewhat embracing contour of the later segments, and the form and position of the aperture are sufficiently characteristic. The more firmly cemented test and darker brown hue of the present species are also features of some comparative value.

Von Hantken has figured a fossil specimen not unlike these in general aspect, and with a similar thin peripheral edge, under the name *Haplophragmium acutidorsatum*;[1] but I am informed by him that the specimens found in the Hungarian Tertiaries are always involute, and that they differ in some other respects from the recent species.

Haplophragmium emaciatum is not by any means a common form. The best examples hitherto met with are from two points in the Danish West Indies, namely:—Station 23, off Sombrero Island, 450 fathoms, and Station 24, off Culebra Island, 390 fathoms.

Haplophragmium fontinense, Terquem (Pl. XXXIV. figs. 1–4).

Haplophragmium fontinense, Terquem, 1870, Mém. Acad. imp. Metz, 1869–70, p. 235, pl. xxiv. figs. 29, 30.

Test planospiral, evolute, much compressed, somewhat irregular, the two sides approximately equal; formed of three convolutions, the outermost consisting of about

[1] Magyar. Földt. Társulat., 1868, vol. iv. p. 82, pl. i. fig. 1.

seven segments, generally supplemented by one or two which are free or non-spiral. Segments somewhat convex, peripheral margins thin. Aperture simple, elongate or oval; situate on the distal face of the terminal segment. Texture coarsely arenaceous, rough externally. Longer diameter, $\frac{1}{11}$th inch (2·3 mm.) or less.

The figures of this species on Pl. XXXIV. closely resemble the single drawing given by Terquem in his third memoir on the Foraminifera of the French Oolite (*loc. cit.*), and the living specimens correspond in general characters with the terms of his description. The size of some of the recent tests considerably exceeds that of the fossil specimens, but this is a variable feature, and one in which much latitude may properly be allowed. In all cases the test is coarsely sandy and very rough. The colour is to a certain extent that of the constituent sand-grains, which are sometimes exceedingly dark; but there is an absence of the predominating brown tint which forms a noticeable feature in many allied species.

The figured specimens are all from the South Atlantic,—Station 323, east of Buenos Ayres, 1900 fathoms. The species occurs also in the South Pacific, on the western coast of South America, between Juan Fernandez and the mainland, 1375 fathoms, and amongst the islands on the coast of Patagonia, 40 to 140 fathoms.

M. Terquem's specimens were obtained from the Oolite (Zone of *Ammonites parkinsoni*) of Fontoy, Moselle.

Haplophragmium rotulatum, H. B. Brady (Pl. XXXIV. figs. 5, 6).

Haplophragmium rotulatum, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 50.

Test spiral, nautiloid, biconcave; umbilicus deeply sunk on both faces, peripheral edge thick and square, often somewhat oblique. Segments numerous, forming about three convolutions, which are visible on both sides of the test; septation obscure. Diameter, $\frac{1}{45}$th inch (0·56 mm.).

This is a sandy isomorph of *Anomalina coronata*, with very distinct morphological characters. The test is smaller than that of *Haplophragmium scitulum*, and the periphery thick and square, not rounded; the walls are coarsely arenaceous, and the exterior very rough.

Haplophragmium rotulatum is comparatively rare, and hitherto has only been met with on very deep bottoms. The finest specimens are from Station 5 and Station 9, two points south-west of the Canaries, depth 2740 fathoms and 3150 fathoms respectively. It occurs also at Station 64, in mid-Atlantic, 2750 fathoms; and at one locality in the deep area of the North Pacific, Station 244, depth 2900 fathoms.

Haplophragmium latidorsatum, Bornemann, sp. (Pl. XXXIV. figs. 7–10, 14).

Nonionina latidorsata, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesell., vol. vii. p. 339, pl. xvi. fig. 4, *a.b.*

Haplophragmium crassum, Reuss, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 46, pl. i. figs. 1, 2.

Lituola subglobosa, M. Sars, 1868, Vidensk.-Selsk. Forhandlinger for 1868, p. 250.

„ „ G. O. Sars, 1871, Ibid. for 1871, p. 253.

Haplophragmium rotundidorsatum, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt., vol. iv. p. 12, pl. i. fig. 2.

„ *subglobosum*, Brady, 1881, Denkschr. d. k. Akad. Wiss. Wien, vol. xliii. p. 100, No. 22.

Test free, nautiloid; subglobular or compressed; consisting of about two convolutions, the later of which completely encloses the earlier. Segments numerous, about six in the outer whorl, often somewhat inflated; septal lines distinct, sometimes sunken or excavated. Aperture a curved slit along the base of the outer face of the final segment; either simple or subdivided into a line of rounded pores. Walls thick, arenaceous; firmly cemented and well-finished; colour light-brown. Diameter, $\frac{1}{11}$th inch (2·3 mm.) or less.

The study of an abundant supply of specimens in the recent condition has convinced me that the *Nonionina latidorsata* of Bornemann, the *Haplophragmium crassum* of Reuss, and the *Lituola subglobosa* of M. Sars, represent only individual modifications of the same specific form, with no claim to be regarded as even varietally distinct from each other; and under these circumstances precedence has been given to the earliest specific name.[1] With regard to the last of these, it may be stated, that although neither description nor figure is furnished by the author, the characters of the Norwegian specimens for which the name was intended are well known.[2] The two forms quoted from Bornemann and Reuss are neither of them quite typical; both are a good deal compressed, one is represented with flush sutures, the other with somewhat inflated chambers and excavated sutures. Similar conditions, exaggerated in degree, are exemplified in Pl. XXXIV. figs. 7 and 8, and it is easily shown that not only these, but specimens to all appearance further apart, represent mere individual modifications of the same typical form. The comparative sphericity or lateral compression of the test, and the degree of inflation of the segments are constantly varying features. In the northern cold deep-sea area explored by Prof. G. O. Sars, *Haplophragmium latidorsatum* exists in enormous numbers, sometimes to the extent of 20 per cent. of the entire weight of the washed and

[1] It is not improbable that the specimen figured by Soldani (*Testaceographia*, vol. ii., pl. xxvi. fig. *N.*) and subsequently named by d'Orbigny *Robulina rugosa* (*Ann. Sci. Nat.*, 1826, vol. vii. p. 290, No. 21) may also belong to this species, but the drawing is too obscure to be identified with any certainty, and it may only represent a fossil Cristellarian.

[2] I am indebted to Prof. G. O. Sars of Christiania for type specimens of this form. It has not been without reluctance that the name employed in the late Prof. M. Sars's list of Norwegian Foraminifera has been abandoned.

dried dredged material,[1] and a very slight examination of specimens brought under notice in multitudes of this sort is sufficient to show the impossibility of subdivision on the basis of the characters alluded to.

As compared with *Haplophragmium canariense*, the test of *Haplophragmium latidorsatum* has thicker walls and is more solidly built. Its involute habit of growth and comparatively small number of segments serve to distinguish it from the allied *Haplophragmium scitulum*. Like other thick-walled *Lituolinæ*, it frequently employs sponge-spicules to a greater or less extent in place of sand-grains in the construction of the test, as shown in the sectional drawing (fig. 10).[2]

A minute, flattened, few-chambered modification of the type occurs in dredged sand from Kandavu, Fiji Islands, 210 fathoms. The specimens, one of which is portrayed in fig. 14, *a. b.*, are so uniform in character, that there appeared at first some reason to regard them as representatives of a distinct variety, but further examination has not confirmed this view.

Haplophragmium latidorsatum is one of the commonest deep-water species of arenaceous Foraminifera. Its area of distribution extends from the shores of Franz-Josef Land, in lat. 79° to 80° N., depth 113 to 135 fathoms, to the Antarctic Ice-barrier, lat. 65° 42′ S.; and the list of localities includes—twenty-four Stations in the North Atlantic, the depths ranging from 390 to 2740 fathoms; six Stations in the South Atlantic, 675 to 2745 fathoms; four in the Southern Ocean, 1300 to 2600 fathoms; twenty in the South Pacific, 147 to 2600 fathoms; and nine in the North Pacific, 2050 to 3950 fathoms.

With regard to its occurrence in the fossil state, I can add nothing to the information furnished by the memoirs referred to in the synonymy, namely, that it has been found in the Septaria-clay of Hermsdorf, near Berlin (Bornemann), in the Salt-clay of Wieliczka in Galicia (Reuss), and in the *Clavulina-szabói* beds of Hungary (Hantken); all of which are of Middle Tertiary age.

Haplophragmium scitulum, H. B. Brady (Pl. XXXIV. figs. 11–13).

Haplophragmium scitulum, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 50.
„ „ Id. 1882, Proc. Roy. Soc. Edin., vol. xi. p. 711.

Test nautiloid, depressed, excavated at the umbilici, rounded at the periphery; composed of about three convolutions, the outermost, consisting of from eight to eleven segments, only partially enclosing the earlier ones. Segments compactly fitted, with little or no external depression at the sutures. Aperture a simple curved slit at the inner

[1] See *Quart. Journ Micr. Sci.*, vol. xxi., N. S., p. 69, under Sars's name *Haplophragmium subglobosum*.

[2] With Moebius this tendency serves as the basis of generic distinction, which is manifestly endowing it with too much importance. His figured specimen, *Raphidohelix eligans*, Foram. von Mauritius, pl. ii. fig. 2, is a marvellous example of spiculiferous test-building.

margin of the final chamber. Shell-wall finely arenaceous, nearly smooth externally, and of clear yellow-brown colour. Diameter, $\frac{1}{30}$th inch (0·8 mm.) or less.

Haplophragmium scitulum has a symmetrical and neatly finished test, slightly evolute, that is to say, the successive convolutions not entirely concealing those previously formed, compressed, and somewhat sunken near the centre on either side. The spire is relatively longer than in the other nautiloid forms of the same genus, and the number of segments in each convolution is larger. Its nearest ally is *Haplophragmium latidorsatum*, and the marked difference in structure presented by the shells of the two species is strikingly shown in the drawings of their respective horizontal sections (Pl. XXXIV. fig. 10, and fig. 13).

Out of a list of eleven localities at which *Haplophragmium scitulum* has been noticed, eight are in the North Atlantic, the area embraced extending from the Faröe Channel to the Cape de Verde Islands and the West Indies, and the range of depth from 530 to 1445 fathoms ; the remainder are,—one in the South Atlantic, east of Buenos Ayres, 1900 fathoms ; one in the South Pacific, west coast of Patagonia, 400 fathoms ; and one in the deep region of the North Pacific, 2900 fathoms.

Haplophragmium glomeratum, H. B. Brady (Pl. XXXIV. figs. 15–18).

Lituola glomerata, Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 433, pl. xx. fig. 1, *a.b.c.*

Haplophragmium glomeratum, Id., 1881, Denkschr. d. k. Akad. Wiss. Wien, vol. xliii. p. 100, No. 21.

Test free, spiral, subglobular or ovate, elongated in the direction of the axis, somewhat sunken at the umbilici ; composed of about two slightly unsymmetrical convolutions. Segments few, three or four in the outer whorl ; short and broad in the direction of growth, inflated. Walls thin, coarsely arenaceous, rough externally. Aperture near the middle of the inner margin of the terminal segment ; often indistinct. Diameter seldom more than $\frac{1}{100}$th inch (0·25 mm.).

This, which is one of the most minute of the spiral *Lituolinæ*, is also one of the most obscure in point of structure, owing to the fact that the septation is often imperfect and the sutures scarcely visible externally. Its structural features may be best understood by imagining one of the nautiloid species, such as *Haplophragmium latidorsatum*, drawn out at the umbilici so as to form a test bearing some resemblance to the oval *Alveolinæ*. It is, however, seldom quite symmetrical, one end being generally broader than the other, and the umbilici are often a good deal excavated. These terms apply to well-grown adult specimens ; the young and minute tests are too indifferently characterised for zoological description.

Haplophragmium glomeratum is common in the Arctic seas. It has been found at

several points in Baffin's Bay and Smith Sound, extending as far north as lat. 81° 41′, at depths ranging from 23 to 220 fathoms, and to almost the same high latitude on the shores of Franz-Josef Land, at 89 to 113 fathoms; thence southward to our own shores, where it has been met with in Portree Bay, Skye, 14 to 18 fathoms (Robertson), and at one or two localities on the east and north-east coast of Ireland (Wright and Balkwill). Its area of distribution in the southern hemisphere stretches to Kerguelen Island, where it is also found in comparatively shallow water, 120 fathoms. In tropical and subtropical latitudes it seeks greater depths. It has been obtained at two Challenger Stations in the North Atlantic, 2675 fathoms and 2740 fathoms respectively, and at one just south of the equator, 2350 fathoms; at three in the South Pacific 2160 to 2425 fathoms; and at one in the North Pacific, off the Philippine Islands, 2550 fathoms.

Haplophragmium canariense, d'Orbigny, sp. (Pl. XXXV. figs. 1–5).

Nonionina canariensis, d'Orbigny, 1839, Foram. Canaries, p. 128, pl. ii. figs. 33, 34.
Placopsilina canariensis, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 301, pl. x. figs. 13, 14.
Nonionina jeffreysii, Williamson, 1858, Rec. For. Gt. Br., p. 34, pl. iii. figs. 72, 73.
Lituola canariensis, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 472.
„ *nautiloidea*, var. *canariensis* (pars), Parker and Jones, 1865, Phil. Trans., vol. clv. p. 406, pl. xv. fig. 45, *a.b.*
Haplophragmium jeffreysii, Berthelin, 1878, Foram. de Bourgneuf et Pornichet, p. 24, No. 20.
„ *canariense*, Siddall, 1879, Catal. Brit. Rec. For., p. 4.

Test free, nautiloid, much compressed; composed of several convolutions, the outermost of which consists of from six to nine segments. Convolutions embracing; the final one almost, sometimes entirely, enclosing those previously formed. Lateral surfaces somewhat concave, umbilici more or less excavated; peripheral edge rounded and slightly lobulated. Aperture arched or oblong, situate at or near the inner margin of the ultimate segment, sometimes surrounded by a projecting border. Walls arenaceous, usually thin and smoothly finished; colour variable, reddish-brown to grey, the later segments often of lighter hue than the rest. Diameter, $\frac{1}{30}$th inch (0·84 mm.).

The typical characters of *Haplophragmium canariense* are well rendered in the drawings (Pl. XXXV. figs. 1, 2, and 3); but like most of its congeners the species is exceedingly liable to variation. This is exhibited to some extent in the texture and minute structure of the test, and to a greater degree in the form and disposition of the chambers.

Under ordinary circumstances the test is very thin and nearly smooth externally; but in some localities specimens are found with walls of much stouter consistence, and constructed of coarser materials, the exterior being correspondingly rough. This variety, of which fig. 4 represents a good example, is not uncommon on the Dogger Bank, and often grows to a comparatively large size, $\frac{1}{20}$th inch (1·26 mm.) in diameter or thereabouts.

In districts where the species abounds, as on the western shores of Scotland, specimens with abnormal characters of one sort or another are very frequent. In most cases the anomalous features consist in nothing beyond the free or irregular growth of a few of the later chambers, or of the more or less evolute arrangement of the convolutions; but occasionally the test is more distinctly monstrous. An example of this kind is seen in fig. 5, which represents a specimen in which the later segments are disposed in alternating series, as in *Textularia*, so that the complete organism has characters approaching those of the dimorphous type, *Spiroplecta*. Such obvious monstrosities are interesting and suggestive from a morphological point of view, but are otherwise comparatively unimportant.

Haplophragmium canariense is of world-wide distribution. It was found in the soundings obtained in the British North-Polar Expedition, as far north as lat. 82° N., and in those of the Austro-Hungarian Expedition to nearly lat. 80° N.; and from these points to Kerguelen Island and Heard Island in the southern hemisphere, it is at home in every sea. It is common in shallow water on the shores of Norway, Great Britain, Belgium, and France; and though at the greater depths of the North Atlantic it is comparatively rare, its occurrence has been noted at 530 fathoms, 540 fathoms, and 1445 fathoms. In the South Atlantic it occurs at five Stations, ranging from 13 fathoms to 1900 fathoms; in the South Pacific at twelve, from 2 fathoms to 2160 fathoms; and in the North Pacific at seven, from 40 fathoms to 3950 fathoms. It may be stated that, except in the North Pacific, by far the larger proportion of the points referred to are in shallow water.

As a Post-tertiary fossil, the species has been collected near Peterborough (Parker), in the west of Scotland (Robertson), in the north-east of Ireland (Wright), and in Norway (Crosskey and Robertson); but its geological history does not appear to extend beyond the Pleistocene period.

Haplophragmium nanum, H. B. Brady (Pl. XXXV. figs. 6–8).

Haplophragmium nanum, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 50.
„ „ Id. 1881, Denkschr. d. k. Akad. Wiss. Wien, vol. xliii. p. 99, pl. ii. fig. 1, *a.–c.*

Test minute, Rotaliform, depressed; consisting of about two convolutions, the outermost of which is composed of six or seven somewhat inflated segments, often irregular in shape and disposition. Superior face flat or only slightly convex; inferior face convex, more or less excavated at the umbilicus. Walls thin; texture resembling that of *Haplophragmium canariense*; colour light-brown, the final segment somewhat lighter than the rest. Diameter, $\frac{1}{75}$th inch (0·34 mm.) or less.

This little variety closely resembles *Haplophragmium canariense*, but the test is

inequilateral and Rotaliform instead of being regularly nautiloid. It is always of small dimensions, seldom much exceeding $\frac{1}{100}$th inch in diameter, and is very liable to irregularity, both in the shape and disposition of the chambers. Referring to the drawings of the species, fig. 6 represents the typical form, whilst figs. 7 and 8 are examples of irregularly grown tests.

The most characteristic specimens of *Haplophragmium nanum* have been obtained from the Arctic seas, especially off Franz-Josef Land, in lat. 79° to 80° N., where it is exceedingly abundant at depths of 89 to 145 fathoms. It also occurs at several points on the western shores of Novaya Zemlya, 55 to 219 fathoms. It has not been noticed in the North Atlantic, but in the South Atlantic it has been found in material from two localities, Station 323, depth 1900 fathoms, and Station 346, depth 2350 fathoms; in the South Pacific, at Station 306, depth 345 fathoms; and in the North Pacific, at Station 253, depth 3125 fathoms.

Haplophragmium turbinatum, H. B. Brady (Pl. XXXV. fig. 9, *a.–c.*).

Haplophragmium turbinatum, Brady, 1881, Quart Journ. Micr. Sci., vol. xxi., N. S., p. 50.

Test Rotaliform; subglobular or depressed; consisting of about two oblique or somewhat irregular convolutions. Superior surface more or less flattened near the centre; inferior side excavated at the umbilicus; periphery thick and rounded. Segments slightly ventricose, numbering about six in the peripheral whorl. Diameter, $\frac{1}{35}$th inch (0·75 mm.).

This species has to some extent intermediate characters. It is Rotaliform and asymmetrical, but otherwise resembles *Haplophragmium latidorsatum;* whilst, on the other hand, though it has many features in common with *Haplophragmium globigeriniforme*, the spire is more depressed and the segments less gobular.

Haplophragmium turbinatum occurs in company with the former of these species at Station 195, off Amboyna, 1425 fathoms; and with the latter, at Station 346, in mid-Atlantic, just south of the equator, 2350 fathoms.

Haplophragmium globigeriniforme, Parker and Jones, sp. (Pl. XXXV. figs. 10, 11).

Lituola nautiloidea, var. *globigeriniformis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 407, pl. xv. figs. 46, 47 (pl. xvii. figs. 96–89 ?).

„ *globigeriniformis*, Wright, 1877, Proc. Belfast Nat. Field Club, 1876–77, App., p. 103.

Haplophragmium globigeriniforme, Siddall, 1879, Catal. Brit. Rec. For., p. 4.

Lituola (*Haplophragmium*) *globigeriniformis*, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 175, pl. i. fig. 3.

Test free or rarely adherent; consisting of a depressed trochoid Rotaliform spire, formed of two to three convolutions, the outermost of which is usually composed of four segments. Segments globular, rapidly increasing in size. Aperture simple, situated at the umbilical margin of the final segment on the inferior side. Walls somewhat coarsely arenaceous, but firmly cemented, and presenting a tolerably well-finished exterior; colour brown. Diameter, $\frac{1}{18}$th inch (1·4 mm.), more or less.

As may be inferred from its name, this species is an arenaceous isomorph of *Globigerina bulloides*. Its characters are exceedingly simple, and the foregoing description needs but few additional remarks. The specimens from different localities vary a good deal in point of size, some being no larger than small *Globigerinæ*, whilst others, living under favourable conditions, attain a diameter of $\frac{1}{18}$th inch, or even more. Under ordinary circumstances the test is free, but occasionally it is met with in the sessile condition, as represented in fig. 11. In such cases it is generally found more or less embedded in loosely aggregated light-coloured sand, corresponding in this respect with adherent varieties of certain other types, notably *Valvulina* and *Truncatulina*.

I have recently received from my friend Mr. Robertson of Glasgow specimens of an arenaceous Foraminifer closely allied to the present species but isomorphous with *Sphæroidina bulloides*. This interesting modification, which I propose to name *Haplophragmium sphæroidiniforme*, was found in sands dredged in the Mediterranean, at depths of 70 to 120 fathoms.

The geographical distribution of *Haplophragmium globigeriniforme* is world-wide. It is essentially a deep-water species, and notwithstanding the occurrence of small specimens at a few localities not far from land, it cannot be said to be at home at depths of less than 400 fathoms or thereabouts. It is not uncommon in the Arctic seas, on the shores of Franz-Joseph Land, as far north as lat. 79° or 80° N., and also in Baffin's Bay; and a few small examples have been taken on our own coast. Its distribution list comprises in addition fifteen Stations in the North Atlantic, at depths ranging from 390 to 2750 fathoms; four Stations in the South Atlantic, 675 to 2350 fathoms; twelve in the South Pacific, 17 to 2425 fathoms; and six in the North Pacific, 15 to 3950 fathoms. It appears also in Parker and Jones's list of Foraminifera obtained at depths of 500 to 700 fathoms in the Red Sea.

The species is figured by Terrigi from specimens found in the Upper Pliocene Sands of Rome; but I find no other record of its occurrence as a fossil.

Haplophragmium anceps, n. sp. (Pl. XXXV. figs. 12–15).

Test irregular and variable, forming a more or less elevated spire; often dimorphous. Segments numerous, inflated, usually four in the outer whorl. Aperture simple, near the umbilical margin of the final chamber. Diameter, $\frac{1}{17}$th inch (1·5 mm.).

In deep-water gatherings rich in arenaceous Foraminifera there often occur, associated with *Haplophragmium globigeriniforme* or with *Verneuilina propinqua*, as the case may be, irregular specimens presenting intermediate characters, the earlier growth of which is frequently bi- or tri-serial as in some of the *Textularinæ*, whilst the later chambers are much inflated, and are arranged more or less on the Rotalian plan. The tests are coarsely arenaceous, and generally of dark-brown colour. The drawings (figs. 12–15) give a fair idea of the forms such specimens assume. They are too frequent to be regarded as mere monstrosities; and as they mark an interesting morphological condition, it appears desirable that they should have a distinctive name.

This variety has been collected as far north as the entrance to Davis Strait, 1750 fathoms (Norman); at Station 24, off Culebra Island, 390 fathoms; at Stations 323 and 332, off the coast of South America, 1900 fathoms and 2200 fathoms respectively; and at Station 299, between Valparaiso and Juan Fernandez, 2160 fathoms. It also occurs in some of the "Porcupine" dredgings from the North Atlantic.

Placopsilina, d'Orbigny.

Serpula, pars, Schroeter [1784], Linné.
Placopsilina, d'Orbigny [1850], Reuss, Parker and Jones, Carpenter, Terquem, Brady.
Lituola, pars, Jones and Parker [1860], Carpenter, Brady, M. Sars.

Test adherent, arenaceous, rough externally; with one or many chambers, of which the cavities are simple and undivided.

The description of the genus *Placopsilina* originally furnished by d'Orbigny, is contained in a brief note in the Prodrome de Paléontologie stratigraphique, vol. ii. p. 96, and is couched in the following terms:—"Ce genre ressemble aux *Truncatulina*, mais est tonjours fixe, et n'a d'ouverture qu' à la partie supérieure de la dernière loge." Nothing is said of the composite or arenaceous structure of the test, but the reference at a subsequent page to one of the figures in Cornuel's memoir on Lower Cretaceous microzoa sufficiently indicates the group of organisms which the author had in view; and the name has been accepted by Reuss, Carpenter, Terquem, and others, in the sense in which it is employed in the present Report.

Some confusion has not unnaturally resulted from the analogous habit of growth presented by this genus and the isomorphous section of the *Trochammininæ;* but amongst recent specimens the rough exterior of the test in *Placopsilina* is readily distinguished from the finely cemented, richly coloured, and often polished surface of the investment of *Webbina*.

The genus *Placopsilina* makes its appearance at the beginning of the Liassic period,

and recurs at various stages of the Lower and Upper Cretaceous formations, but hitherto it does not appear to have been met with in later microzoic deposits.

Placopsilina bulla, H. B. Brady (Pl. XXXV. figs. 16, 17).

Placopsilina bulla, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 51.

Test adherent; consisting of a single, highly convex or approximately hemispherical chamber, slightly longer in one direction than the other. Aperture a simple, rounded, pouting orifice at each end of the test, close to the base. Cavity undivided; walls thick, somewhat loosely sandy. Diameter, $\frac{1}{35}$th inch (0·73 mm.).

This little organism, the simple characters of which will be readily understood by the figures, affects deep water, and is generally found growing adherent to the tubes of *Rhabdammina* or other arenaceous Rhizopods. The figured specimens are from the South Atlantic, east of Buenos Ayres, 1900 fathoms. It occurs also attached to *Rhizammina*, at Station 299, on the Pacific coast of South America, west of Valparaiso, 2160 fathoms; and in Dr. Carpenter's collection there are numerous examples of the species from "Porcupine" Stations in the North Atlantic, notably from No. 19, west of the north of Ireland, 1366 fathoms.

Placopsilina cenomana, d'Orbigny (Pl. XXXVI. figs. 1–3).

"Œufs de Mollusques," Cornuel, 1848, Mém. Soc. géol. France, sér. 2, vol. iii. p. 259, pl. ii. fig. 36.
Placopsilina cornueliana, d'Orbigny, 1850, Prodr. Paléont., vol. ii. p. 111, No. 791.
„ *cenomana*, Id. Ibid. p. 185, No. 758.
„ „ Reuss, 1854, Denkschr. d. k. Akad. Wiss. Wien, vol. vii. p. 71, pl. xxviii. figs. 4, 5.
Lituola cenomana, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 302, Table, No. 182.
Lituola (*Placopsilina*) *cenomana*, Carpenter, 1862, Introd. Foram., p. 143, pl. xi. figs. 11–14.
Placopsilina prolifer, Terquem, 1866, Foram. du Lias, 6me Mém., p. 493, pl. xx. fig. 24.
„ *hybrida*, Id. Ibid. p. 494, pl. xx. figs. 25, 26.
Lituola cenomana, Brady, 1867, Proc. Somerset Arch. and Nat. Hist. Soc., vol. xiii. p. 105, pl. i. fig. 1

Test adherent; spiral, crosier-shaped, or linear, rarely branching; consisting of a number of convex chambers closely approximated and arranged, often very irregularly, in single series. Aperture simple, terminal. Length, very variable; in large specimens sometimes $\frac{1}{5}$th inch (5 mm.) or more.

Three species of *Placopsilina* are enumerated in the Prodrome de Paléontologie namely:—*Placopsilina neocomiensis*, *Placopsilina cornueliana*, and *Placopsilina*

cenomana. Of the first of these no descriptive characters are given, nor any reference to published figures, so it may be entirely ignored; of the second, *Placopsilina cornueliana*, no description is given, but reference is made to some very characteristic drawings in Cornuel's memoir on Cretaceous microzoa (*loc. cit.*); whilst to *Placopsilina cenomana* nothing but the following note is appended:—"Espèce contournée en crosse adhérente aux corps." That the two latter specific terms are synonymous, and apply to mere individual modifications of the same typical form, there cannot be any doubt; and it is a matter for regret that the ill-defined "*cenomana*" should have been perpetuated by Reuss, to the exclusion of a name founded on an authentic figure and dedicated to the discoverer of the organism.

Placopsilina cenomana is a very variable species. The test consists of a single line of chambers generally arranged at its commencement in a flat spire, but diverging at a later stage and taking a straight, curved, or very irregular course. Hence it may be entirely spiral like an attached *Truncatulina*, or crosier-shaped, or indefinitely spreading, the contour depending in part on the nature of the body to which it is attached.

The species differs from the allied *Bdelloidina aggregata* in that the chamber-cavities are undivided and the aperture single, whilst the latter form has labyrinthic chambers and a porous aperture. Its closely approximated chambers and rough exterior serve to distinguish it from the isomorphous *Webbina irregularis*, which has rounded and distinct segments and a comparatively smooth surface.

Placopsilina cenomana occurs at one "Porcupine" Station, west of Ireland, 670 fathoms, which supplies the only record of its existence in the North Atlantic. It is named in one of Parker and Jones's distribution tables at two localities in the Mediterranean,—off Crete, 360 fathoms, and in Suda Bay, Crete, 40 fathoms; and I have specimens from the late Mr. M'Andrew's dredgings in the Gulf of Suez, 30 fathoms. It has been found at one Challenger Station in the South Atlantic, south of Pernambuco, 350 fathoms, and at five or six amongst the coral-reefs of the Pacific, at depths varying from 3 fathoms to 35 fathoms. It is by no means a common form, except in the shallow water of tropical and subtropical seas.

The geological history of the species commences with the Lower Lias marls of the west of France: it is found in the Middle and Upper Lias of both France and England, and again in the Lower Oolite; also in Cretaceous deposits of various ages in numerous localities in France and in the Eastern Alps; but there does not appear to be any record of its existence in formations of later geological age.

Placopsilina vesicularis, H. B. Brady (Pl. XXXV. figs. 18, 19).

Placopsilina vesicularis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 51, pl. v. fig. 2.

Test irregular in shape and size, spreading in indefinite patches over stones; usually

composed of several convex chambers, either connected by short stoloniferous passages or crowded one against the other; margins rounded or lobulate, with simple or forked tubular extensions which form the pseudopodial apertures.

In *Placopsilina vesicularis* the segments are characterised by their inequality of size and shape, and their irregular combination. In these particulars it differs from *Placopsilina cenomana*, in which the chambers are of more even dimensions, and are combined in single linear series. Monothalamous specimens are less convex than *Placopsilina bulla*, and generally have several peripheral orifices, as shown in fig. 19.

With the exception of a single locality in the South Atlantic east of Buenos Ayres, 1900 fathoms, where the ground is extremely rich in arenaceous Rhizopods, *Placopsilina vesicularis* has only been obtained from dredgings taken on the first cruise of the "Porcupine," between the north-west of Ireland and the Rockall Bank. It occurs at three Stations in this region, at depths of 630 fathoms, 1215 fathoms, and 1443 fathoms respectively.

Haplostiche, Reuss.

Nodosaria, pars, d'Orbigny [1826].
Lituola, pars, Jones and Parker [1860], Carpenter, Vanden Broeck, Brady.
Haplostiche, Reuss [1861], Brady, Seguenza, Bütschli.

Test free, coarsely arenaceous; composed of a number of segments joined together in a straight or curved (never spiral) series. Chambers labyrinthic. Aperture terminal; porous or dendritic, rarely simple.

Although in the original description of the genus *Haplostiche* prominence is given to the subdivision of the chambers by secondary septa, and to the variable nature of the aperture, the term was in reality made use of by Reuss for all the Nodosariform *Lituolinæ;* and neither in his essay on classification,[1] nor in his final arrangement of the *Lituolidea*[2] did the author provide for the linear forms which have simple chamber-cavities. The oversight is no doubt due to the fact that the arenaceous types were studied chiefly from fossil specimens, and that chambers filled by mineral infiltration were not always in a state in which the characters of the interior could be properly determined. Arenaceous isomorphs of the Nodosariæ are altogether less common in the fossil than in the recent condition, if we may judge by the comparatively small number of species that have hitherto been described; but it is possible that the proportion of labyrinthic to simple types may be relatively larger. It cannot be stated with any certainty whether all Reuss's species of *Haplostiche* accord with the characters

[1] *Sitzungsb. d. k. Ak. Wiss. Wien*, 1861, vol. xliv. p. 381.
[2] Das Elbthalgebirge in Sachsen, 2ter Th., 1874, p. 119.

laid down by him for the genus, because no figures are given which throw any light upon their internal structure, but many of them closely resemble recent non-labyrinthic forms. Be that as it may, the generic term *Haplostiche* serves a useful purpose, and has been retained under its original limitations for the straight or curved linear species with labyrinthic chambers; whilst Montfort's name *Reophax*, which was treated by Reuss as a synonym only, has been rehabilitated for the more numerous series in which the cavities are undivided.

Haplostiche soldanii, Jones and Parker, sp. (Pl. XXXII. figs. 12–18).

"Orthoceratia *Zoophytica* minuscula," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 93, pl. xcviii. fig. *A*.

"Orthoceras *Trochus*," Id. 1798, Ibid., vol. ii. p. 16, pl. iii. fig. *c.c.*—Saggio Orittog., p. 135, pl. xix. fig. 92, *Z*.

Nodosaria dubia, d'Orbigny, 1826, Ann. Sci. Nat., vol vii. p. 252, No. 10.

Lituola soldanii, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 307, No. 184.

„ *dubia*, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 263, pl. ix. fig. 30.

„ *soldanii*, var. *intermedia*, Vanden Broeck, 1876, Ann. Soc. Belg. Micr., vol. ii. p. 74, pl. ii. figs. 1, 3, 4, 6.

Test elongate, subcylindrical or ovate, inferior end round or tapering to a blunt point, superior end broad and rounded; consisting of numerous, convex, slightly embracing chambers, superimposed in a straight or somewhat curved line. Exterior rough, but little constricted at the sutures; interior of the chambers subdivided by irregular secondary septa. Aperture terminal; porous or dendritic. Length of large specimens, $\frac{3}{10}$th inch (7·5 mm.).

The recent specimens of the genus *Haplostiche* may all be assigned to a single species. They present, nevertheless, a great variety of contour, ranging from such forms as the *Nodosaria dubia* of d'Orbigny, of which the short, broad shell portrayed in fig. 14 is an instance, to the long and narrow *Lituola soldanii*, var. *intermedia* of Vanden Broeck, which closely resembles figs. 12 and 13. In the absence of any described species to which the bulk of their specimens could be properly referred, Messrs Jones and Parker, many years ago, selected two of Soldani's figures, which appeared to exemplify average characters, as representatives of the type, and named them after their discoverer *Lituola soldanii*. With these as central forms, the recent examples constitute a single very natural specific group. When a number of specimens are examined together, it becomes evident at once that there is no basis for subdivision into varieties; for whilst the extreme modifications are widely different in external characters, no two specimens are alike, and every link in the intermediate series is easily found.

Haplostiche soldanii is not likely to be confounded with any other of the *Lituolidæ*,

but it may easily be mistaken for *Clavulina cylindrica*, as a comparison of figs. 12 and 13 with some of the drawings of the latter species (Pl. XLVIII. figs. 32 and 34) is sufficient to show. The external resemblance of these two forms is very close, though their internal structure, as seen in their respective longitudinal sections, is altogether different; but they may almost invariably be distinguished from each other by the character of the aperture, which in the one case is porous or dendritic, and in the other consists of a round orifice, partially closed by a valvular tooth.

The labyrinthic condition of the chamber-cavities, which constitutes the peculiar feature of the genus, is illustrated by figs. 16, 17, 18.

In the recent condition, *Haplostiche soldanii* is best known as a West Indian species. It has been obtained from sands dredged off Jamaica, 50 to 100 fathoms (Jones and Parker), and off Barbados, 100 fathoms (Vanden Broeck), and some of the largest Challenger specimens were collected off Culebra Island, 390 fathoms, and off Bermuda, 435 fathoms. It has also been taken off the coast of South America, south of Pernambuco, 350 fathoms; and off Rio Janeiro; on the west coast of New Zealand, 275 fathoms; and off Kandavu, Fiji Islands, 210 fathoms; and lastly there are, in Prof. Parker's collection, a number of specimens from the Abrolhos Bank, 40 to 47 fathoms.

The species is also well known as a Tertiary fossil. It was first obtained by Soldani from the Subapennine deposits of Sienna and San Quirico, in Tuscany, and has been found by later palæontologists in rocks of middle and later Tertiary age in various parts of the world:—in the Miocene beds of Malta, and of the neighbourhood of Malaga; in the yellow Miocene limestone and the Pteropod-marl of Jamaica; in the sandy Miocene clays of San Domingo; and in the Pliocene marl of Porto Limon, in Costa Rica.

Bdelloidina, Carter.

Bdelloidina, Carter [1877], Brady.

The essential features of the genus *Bdelloidina* are the arenaceous texture of the test, its adherent habit of growth, and the labyrinthic subdivision of the chambers. As our knowledge of the type extends only to the characters displayed by a single species, *Bdelloidina aggregata*, the account of its structural peculiarities may be reserved for the description of that form.

Bdelloidina aggregata, Carter (Pl. XXXVI. figs. 4–6).

Bdelloidina aggregata, Carter, 1877, Ann. and Mag. Nat. Hist., ser. 4, vol. xix. p. 201, pl. xiii. figs. 1–8.

Test adherent, depressed; consisting of a number of closely approximated chambers, arranged more or less regularly in a single, simple or branched, linear series, and intercommunicating by a row of pores on each septal face. Segments very short (on the

axis of growth) and broad; curved or irregular in outline; subdivided more or less completely by numerous secondary septa. Walls rough externally, interior surface smooth. Aperture porous. Diameter of the adherent patches $\frac{1}{6}$th inch (4 mm.) or more.

Bdelloidina aggregata is generally met with in the form of little, grey, sandy, spreading patches, growing on fragments of shell or coral, usually selecting some hollow or cranny, where it is protected by its position from external injury. Under the microscope it is found to consist of a more or less complicated mass of segments, arranged in somewhat irregular, broad, either simple or divided lines, often a good deal crowded together.

The segments are long and very narrow, and are placed side by side, so that their length lies transversely to the axis of growth. Owing to the nature of the bottom in the localities which the organism affects, the test is usually constructed of calcareous rather than siliceous sand. The exterior is rough, and the sutural lines distinct and slightly excavated.

The cavities of the chambers are irregularly divided by transvere partitions, as shown in fig. 6; but the subdivisions of the adjacent chambers do not correspond in size or position, nor are they indicated in any way on the exterior of the test. The interior surface is smooth, and is marked by punctations which have the appearance of large pores. A very similar condition is presented by the inner surface of the shell of *Trochammina trullissata* (Pl. XL. fig. 16). In that species it can be easily demonstrated that the test is not really perforated, and that the markings only represent a very early or rudimentary condition of the cancellated structure which finds its fullest development amongst recent types in the genus *Cyclammina;* and as no pores are visible externally in the test of *Bdelloidina*, it is probable that in *Bdelloidina* also the puncta on the internal surface are mere superficial depressions.

The general aperture of the test is very distinctive: following the common rule of labyrinthic Foraminifera, it is cribrate or porous, and takes the form of a single row of round orifices on the outer face of the terminal chamber, as shown in figs. 4 and 5.

Bdelloidina aggregata is manifestly a rare species. The Challenger specimens, which are few in number, were all obtained from two or three dredgings in shallow water near the Admiralty Islands, on the north coast of Papua, and they are generally adherent to fragments of molluscan shells. Mr. Carter gives no locality for those which form the subject of his paper, but states that they were found "in excavations on the surface of a large globular mass of *Siderastræa.*"

Prof. Rupert Jones has for many years had in his possession a characteristic drawing of this species, taken from a fine specimen adherent to a Cretaceous Ammonite in Mr. Matthew Wright's cabinet. Probably the examination of the surface of Mesozoic fossils would bring to our knowledge other examples of this sort.

Sub-family 2. Trochammininæ.

Thurammina, H. B. Brady.

Lituola, pars, Carpenter [1875].
Thurammina, Brady [1879], Bütschli, Carpenter, Uhlig, Haeusler.

Test (typically) free; consisting of a single round, ovate, compressed, or irregularly-shaped chamber, sometimes enveloping one of smaller size. Surface beset with numerous perforated nipple-like protuberances. Walls thin, arenaceous, rarely chitino-arenaceous.

The genus *Thurammina* takes the place in arenaceous series that *Orbulina* occupies amongst the hyaline Foraminifera. As a generic group it presents a considerable range of characters, both in the contour and the minute structure of the investment. In its normal or typical form the test is nearly spherical, the walls being usually very thin; and it has nipple-like orifices scattered over the surface, which are probably homologous with the larger set of pores in the *Orbulinæ*.

In the living condition *Thurammina* is very widely distributed. It is found in all the great ocean basins, preferring as a rule the deeper areas. Out of twenty-six recorded localities, eighteen have depths set down at more than 1000 fathoms, and six at more than 2000 fathoms.

No fossil representatives of the type were known, until the late publication by Dr. V. Uhlig of a brief paper on Jurassic Foraminifera,[1] in which certain Rhizopods closely resembling the living varieties of *Thurammina* were described, from specimens found in beds of Upper Jurassic age at Olomutschan near Brünn in Austria, and from similar formations in Wurtemberg. Some of these, which Dr. Uhlig has been good enough to send to me for identification, appear to have all the characters of the genus, if not of the actual species, exemplified by the living forms. Still more recently Dr. R. Haeusler of Brugg has obtained well-characterised examples of the type from the Jurassic formations of Switzerland, a fact which he has kindly enabled me to verify by the examination of numerous specimens.

Thurammina papillata, H. B. Brady (Pl. XXXVI. figs. 7–18).

"Orbuline *Lituola*," Carpenter, 1875, The Microscope, 5th ed., p. 533, fig. 273, *g. h.*
Thurammina papillata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 45, pl. v. figs. 4–8.
,, ,, Carpenter, 1881, The Microscope, 6th ed., p. 561, fig. 320, *g. h.*
,, ,, Haeusler, 1883, Ann. and Mag. Nat. Hist., ser. 5, vol. xi. p. 262, pl. viii.

Test typically free, and consisting of a single spherical chamber, the surface of which is studded with irregularly disposed perforated papillæ; rarely adherent; not

[1] Ueber einige oberjurassische Foraminiferen mit agglutinirender Schale. *Neues Jahrb. für Min., &c.*, 1882, vol. p. 152.

unfrequently assuming oval, compressed, subangular, or altogether irregular forms. Colour brown; shell-wall very thin, composed of light-coloured sand-grains, fitted together accurately and firmly with reddish-brown cement. Diameter from $\frac{1}{60}$th to $\frac{1}{20}$th inch (0·4 to 1·3 mm.).

Thurammina papillata is a very variable species, and the foregoing summary of its typical characters is based upon average specimens, such as that represented in Pl. XXXVI. fig. 7. In order to arrive at a correct estimate of its morphological range, some of the more important deviations from the typical structure may be briefly described.

Normally the test is free; nevertheless in localities where the species is abundant small specimens are not unfrequently met with in the sessile condition shown in fig. 11, and in these the shape is more or less modified to suit its altered external relations. Occasionally two or three spheres are found attached to each other, as in fig. 15. Such specimens appear to be the result of the adherent growth of several independent tests, which do not assume a corporate existence as a single polythalamous organism; or, in other words, the polythalamous condition depends upon mere superficial adhesion, and not upon the division of the sarcode into segments connected with each other by proper stolons, and forming a corresponding shelly investment.

Sometimes, though very rarely, on breaking a sphere, a second smaller chamber is found in the interior. An example of this sort is represented in fig. 12, and primordial chambers from other specimens, with the papillæ projecting in the form of tubes of various lengths, are shown in figs. 13 and 14. The occurrence of such specimens is exceedingly interesting as a point of analogy between *Thurammina* and *Orbulina*.

The external contour of the test is influenced by other circumstances besides its occasional adherent growth, and the most common departures from the normal spherical form are either in the direction of mere asymmetry (fig. 10), or of elongation in one direction, so as to produce an ovate test (fig. 8), the latter being more especially noticeable in large specimens. These remarks apply mainly to recent tests. The Jurassic examples of the species present much greater diversity of contour, and comparatively few of them show any degree of external symmetry.

The oral papillæ vary in number from half a dozen to a hundred or more, and it by no means follows that the largest test has the most numerous apertures; often quite the reverse is the case. They are sometimes placed with a certain degree of regularity as to their distance apart (fig. 7), and in rare instances are arranged in lines (figs. 9, 10); but in a general way they are scattered over the surface of the test, apparently without law or order. In some specimens, especially amongst those of medium or small size, one of the papillæ is more or less elongated, so as to form a tubular neck, like that of an ectosolenian *Lagena*, as in figs. 9, 10, 11, and 15. The papillæ are probably, as a rule,

all perforated, but the orifices are often indistinct, owing perhaps, as in some of the larger Arenacea, to their being filled with loosely-packed sand or mud.

The minute structure of the test varies according to the external conditions under which the animal has lived. The wall is constructed of angular sand-grains accurately fitted to each other, and firmly compacted by a cement of dark reddish-brown colour. Its general characters, as revealed by a magnifying power of 100 diameters, are well illustrated by the drawings:—fig. 16 is taken from a small thin-shelled specimen; fig. 17 from a larger, stoutly-built, somewhat rough test; and fig. 18 from one of the smoother-shelled varieties, in which very fine sand has been employed as building material.

Finally, the range in size is not less considerable than in other particulars; a number of specimens which have been measured have been found to vary in diameter from $\frac{1}{110}$th to $\frac{1}{15}$th inch (0·23 to 1·7 mm.).

The distribution of *Thurammina papillata* is world-wide, and is governed apparently by the depth of the sea-bottom rather than by latitude or climate. It is at home only in deep or moderately deep water, and the presence of a single specimen in the dredging off Loch Scavaig, on the west coast of Scotland, 45 to 60 fathoms, is manifestly exceptional. In the North Atlantic the species occurs at eight "Porcupine" Stations, lying north-west of Ireland, the depths ranging from 630 to 1476 fathoms; at three points in the Faröe Channel, both in the warm and cold areas, 540 to 560 fathoms; and nearer the equator, at three Challenger Stations, 390 to 2740 fathoms. In the South Atlantic it appears at six Stations, the depths ranging from 350 to 2350 fathoms; in the Southern Ocean, south-east of the Cape of Good Hope, 1570 fathoms, and south of Australia, 2600 fathoms; in the South Pacific, 1825 fathoms; in the North Pacific, 2050 fathoms, and again, just under the equator, 2425 fathoms.

It has already been stated that Dr. Uhlig has discovered specimens pertaining to the genus *Thurammina* in beds of Jurassic age in Austria and Wurtemberg. Since these sheets have been in the hands of the printer Dr. Haeusler has published a description of a remarkable series of specimens of the present species from the Jurassic formations of Switzerland. These were found at various horizons, but, as stated by the author, "in greatest number in the deposits of true deep-sea character, much more rarely and less typical specimens in those formed at moderate depths."

Thurammina albicans, H. B. Brady (Pl. XXXVII. figs. 2–7).

Thurammina albicans, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 46.

Test spherical, or nearly so; with few, usually about six, mammillate orifices, equidistant and regularly disposed. Walls somewhat thicker than those of the type; texture very finely arenaceous; colour nearly white. Diameter about $\frac{1}{90}$th inch (0·28 mm.)

This is an exceedingly rare species. The test is of smaller dimensions than that of the typical *Thurammina papillata;* the walls are relatively thicker, and constructed of finer materials less compactly cemented. The nearly white colour is also a very distinctive feature. The little mammillate protuberances, instead of being numerous and distributed irregularly over the surface, are few in number, and placed more or less symmetrically.

The only locality in which more than a single specimen of *Thurammina albicans* has been met with is Station 323, off the coast of South America, in about the latitude of Buenos Ayres, depth 1900 fathoms; and even there it is by no means abundant.

Haeusler mentions the occurrence of fossil specimens presenting similar characters in later Jurassic rocks of Switzerland.

Thurammina compressa, H. B. Brady (Pl. XXXVII. fig. 1).

Thurammina compressa, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 46, pl. v. fig. 9.

Test rounded, compressed, sublenticular; with numerous perforated mammillate protuberances arranged irregularly on the periphery. Walls thin, chitino-arenaceous; colour dark-brown. Diameter about $\frac{1}{50}$th inch (0·5 mm.).

This also is a scarce modification of the type. It is distinguished by its membranous, only slightly arenaceous test, and its compressed almost lenticular contour. It is possible that the latter character may be in a measure accidental, and due to the partial collapse of the more or less flexible walls, as not unfrequently occurs in other chitino-arenaceous forms, as, for example, in *Trochammina macrescens.* At the same time, the position of the mammillate orifices, on the peripheral margin, and not on the lateral faces of the test, makes it more likely that the natural form is retained by the dried specimens.

Thurammina compressa has only been found at a solitary Station in the North Atlantic, south of the Rockall Bank, 630 fathoms.[1]

Hippocrepina, Parker.

Hippocrepina, Parker [1870], Brady.

As only a single species of this genus is known to zoologists, the generic and specific characters may be included in the same description.

[1] In the preliminary account of this species, the depth was accidentally misstated.

Hippocrepina indivisa, Parker (Pl. XXVI. figs. 10–14).

Hippocrepina indivisa, Parker, 1870 (in Dawson's paper), Canad. Nat., N. S., vol. v. p. 176, p. 180, fig. 2.
„ „ Brady, 1881, Denkschr. d. k. Akad. Wiss. Wien, vol. xliii. p. 101, pl. ii. figs. 3, 4. — Ann. and Mag. Nat. Hist., ser. 5, vol. viii. p. 407, pl. xxi. figs. 3, 4.

Test free, monothalamous; elongate, straight or somewhat curved; superior or oral end broad and rounded; inferior tapering to a blunt point and closed. Aperture a wide curved slit, often irregular, set in a raised collar at the centre of the broad end of the test. Walls thin and finely arenaceous; colour reddish-brown at the point, lighter towards the oral end. Length, about $\frac{1}{25}$th inch (1 mm.).

This pretty little species is interesting alike from its structural peculiarities and its extremely limited distribution.

Its general contour is that of a somewhat irregular, much elongated cone, with the aperture at the broad end. The walls are thin, and their texture is very similar to that of the smooth *Trochamminæ*. The interior of the test forms a single undivided chamber. Occasionally slight transverse superficial depressions, scarcely amounting to constrictions, may be noticed, but whether these merely indicate stages of growth, or are the remains of abortive segmentation, there is nothing to show. The aperture is a curved and gaping slit, something like a horse-shoe in typical specimens, but more frequently of very irregular outline, and is usually surrounded by a raised rim or collar. The test seldom exceeds a millimetre in length, and is often much less.

Hippocrepina indivisa was first obtained by Dr. G. M. Dawson, in Gaspé Bay, at the mouth of the River St. Lawrence, at depths of 16 to 20 fathoms, and the drawings (Pl. XXVI. figs. 10–14) are from specimens from that locality kindly furnished by him. The Rev. A. M. Norman has good examples from one of the "Valorous" dredgings in Holsteinborg Harbour, Greenland, 10 fathoms; and I have myself found the species in a sounding made by Capt. Markham in the Matyushin Shar, Novaya Zemlya, 10 to 15 fathoms. These three localities include all that is at present known of its distribution.

Hormosina, H. B. Brady.

Hormosina, Brady [1879], Bütschli, Carpenter.

Test free, polythalamous (rarely monothalamous); consisting typically of a series of subglobular, fusiform, or pyriform chambers, joined end to end in single moniliform series. Walls thin, smooth externally; texture finely arenaceous; colour various shades of brown.

The genus *Hormosina* comprehends the moniliform section of the *Trochammininæ* and occupies the same position in the group that *Reophax* takes amongst the rougher

Lituolidæ. Under ordinary circumstances, there is no difficulty in distinguishing the *Hormosinæ* from their larger Lituoline isomorphs, by their thin walls and smooth, almost homogeneous, tests, and amongst the smaller species by their regularity and symmetry of form.

In point of distribution *Hormosina* is essentially a deep-water type. Except possibly in the Jurassic formation of Switzerland (Haeusler), no representative of the genus has been found in the fossil state.

Hormosina globulifera, H. B. Brady (Pl. XXXIX. figs. 1–6).

Hormosina globulifera, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 60, pl. iv. figs. 4, 5.
„ „ Carpenter, 1881, The Microscope, 6th ed., p. 561, fig. *c*.

Test composed of a single spherical chamber with a tubulated orifice, or of several (2 to 6) such chambers, each larger than its predecessor, and more or less embracing it. Segments arranged in straight or curved linear series, and terminating in a narrow tubular neck, which serves as the general aperture. Walls thin, texture very finely arenaceous, surface smooth. Length of polythalamous specimens, $\frac{1}{8}$th inch (3 mm.) or less.

Adult specimens of *Hormosina globulifera* have chambers varying in number from one to five or six, and the species affords frequent examples of the tendency, not uncommon amongst the Foraminifera, to cease growing after the production of a segment of relatively large size. As a rule, the specimens which have the greatest number of segments are those with the smallest initial chambers; and, on the other hand, if a very large primordial chamber is formed, the test usually remains monothalamous, and no further growth takes place. This is well illustrated by a comparison of the Lageniform specimen (Pl. XXXIX. fig. 1), with the earlier segments of figs. 3 and 4; and it will be further observed how nearly the dimensions of the arrested monothalamous test approach those of the final segments of figs. 2, 3, and 4 respectively. In the somewhat anomalous specimen (fig. 5) a second large chamber has been formed before growth has ceased.

The same rule which applies to the first chamber in the present species holds good also, more or less, during the later stages of growth amongst Foraminifera generally; and it may often be noticed, in calcareous as well as arenaceous species, that with the formation of a chamber of abnormal size, the growth, that is to say, the continued production of sarcode-segments, comes to an abrupt termination. But whatever may be the significance of monothalamous as distinct from polythalamous tests amongst the Rhizopoda of other groups, the character in the present case is not even of varietal importance.

The only species with which *Hormosina globulifera* is likely to be confounded is *Reophax pilulifera*, and from this it may generally be distinguished by its thinner walls and finer texture, and by its smooth and neatly finished exterior.

Hormosina globulifera inhabits all the great ocean basins. It has been found in material from nine Stations (Challenger and "Porcupine") in the North Atlantic, the depths ranging from 440 to 2740 fathoms; at three Stations in the South Atlantic, 1900 to 2350 fathoms; at six in the South Pacific, 400 to 2160 fathoms; and at three in the North Pacific, 2050 to 2900 fathoms. Thus it is peculiarly a deep-water organism; for out of the twenty-one Stations enumerated, only five have a depth of less than 1000 fathoms, whilst nine are between 1000 and 2000, and seven above 2000 fathoms.

Hormosina ovicula, H. B. Brady (Pl. XXXIX. figs. 7–9).

Hormosina ovicula, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 61, pl. iv. fig. 6.

Test long and very slender, tapering; composed of several fusiform segments joined end to end, without overlapping, in straight or slightly curved linear series. Walls thin, texture very finely arenaceous. Colour yellowish-brown, with a band of somewhat darker hue encircling the narrowest part of the stoloniferous tubes. Length, $\frac{1}{6}$th inch (4 mm.).

A very delicate fragile little organism, seldom found entire. *Hormosina ovicula* stands in much the same relation to *Hormosina globulifera* that *Nodosaria pyrula* does to *Nodosaria radicula;* that is to say, its segments are drawn out at the two ends and are joined by their narrow extremities, instead of the successive lobes being sessile and more or less embracing. The deepening of the brown colour in portions of the test, which has been noticed in connection with other species, shows itself in the present instance in the little ring surrounding the stoloniferous tubes at their narrowest point; each of these points having been of course, in its turn, the general pseudopodial aperture.

Hormosina ovicula is, to even a greater degree than its congener, *Hormosina globulifera*, a deep-water species, for in no case has it been found at a less depth than 1000 fathoms, and in only two out of the eleven recorded localities at less than 1900 fathoms. In the North Atlantic the species is almost unknown, its record being limited to one or two specimens at a single locality off the American coast, in about the latitude of New York, 1350 fathoms. It has been collected at two points in the South Atlantic, Stations 323 and 332, depth 1900 and 2200 fathoms; and at two in the Southern Ocean, Stations 157 and 160, depth 1950 and 2600 fathoms respectively. The remaining six localities are all in the Pacific, two of them just south of the equator, the rest in the northern area, the depths ranging from 1075 to 3950 fathoms.

Hormosina carpenteri, H. B. Brady (Pl. XXXIX. figs. 14–18).

"Moniliform *Lituola*," Carpenter, 1875, The Microscope, 5th ed., p. 531, fig. *f*.
Hormosina carpenteri, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 51.
„ „ Carpenter, 1881, The Microscope, 6th ed., p. 563, fig. *f*.

Test composed of numerous segments, connected end to end in a curved or crooked, never (as a rule) in a straight, line. Segments elongate, pyriform; rounded at the base,

tapering towards the anterior extremity; nearly uniform in size, or slightly increasing in dimensions towards the distal end of the test. Walls finely arenaceous, compactly cemented, and nearly smooth on both the inner and outer surface, except when irregularity is produced by the presence of sponge-spicules only partially incorporated. Length, $\frac{1}{2}$ inch (12·5 mm.) or more.

The large moniliform tests of this species are conspicuous amongst the Rhizopoda of deep-water dredgings in the North Atlantic. Some of the specimens in Dr. Carpenter's collection measure $\frac{8}{10}$th inch (20 mm.) in length, and though examples of this size are rarely met with, there is no other Nodosariform Foraminifer that attains the same average dimensions. The test differs from that of other large species by its invariably crooked and irregular contour, and monstrous specimens are of frequent occurrence. It would be impossible in any limited space to illustrate fully the variety of form the organism assumes, but the drawings (figs. 14–17) convey a just idea of its external appearance; and that of the section (fig. 18) shows the substance and general character of the investing wall.

Hormosina carpenteri is almost distinctively a North Atlantic species. Out of sixteen localities at which its presence has been ascertained, only two are in the southern hemisphere. One of these is in the South Atlantic, Station 122, south of Pernambuco, 350 fathoms; the other in the South Pacific, Station 280, Low Archipelago, 1940 fathoms. In the North Atlantic it occurs at intervals from the Faröe Channel and the west coast of Ireland to the shores of North America; and from the Azores and Canary Islands to the West Indies. Except on the Rockall Bank, where the depth is only 54 fathoms, the recorded bathymetrical range is from 440 to 1750 fathoms.

Hormosina monile, H. B. Brady (Pl. XXXIX. figs. 10–13).

Hormosina monile, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 52.

Test composed of numerous segments connected end to end in a straight or bent linear series. Segments short, subglobular, and nearly uniform in size. Walls finely arenaceous, compactly cemented, and nearly smooth both on the inner and outer surface; colour light ruddy brown. Length, about $\frac{1}{4}$th inch (6 mm.) or less.

This variety closely resembles *Hormosina carpenteri* in its general characters, but is distinguished by its comparatively small dimensions, its short rounded segments, and its less irregular contour. In some of the specimens the surface of the test is more or less hispid, the roughness being due to the free ends of sponge-spicules which have been only partially embedded in the calcareous cement. A similar condition is frequently observed in *Hormosina carpenteri*.

Hormosina monile has only been met with in one locality, Station 122, off the coast of South America, south of Pernambuco, 350 fathoms, where it is found in company with allied arenaceous forms.

Hormosina normani, H. B. Brady (Pl. XXXIX. figs. 19–23).

Hormosina normani, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 52.

Test irregular, composed of few spherical segments, of which those at the commencement are relatively small and the final one usually very large. Aperture seldom at the apex or distal end of the chambers, but often at some point of the periphery very near to the entrance of the last stoloniferous tube; so that the new segment is sometimes put on obliquely, sometimes at right angles to the previous one, or not unfrequently directed backwards. Walls very thin in proportion to the bulk of the segments; both the internal and external surface smooth. Length, about $\frac{1}{3}$rd inch (8 mm.).

A very rare species, characterised by its large globular chambers and their irregular disposition. In one example the final segment considerably exceeds $\frac{1}{8}$th inch (3 mm.) in diameter. The test is exceedingly fragile, and is seldom found entire, owing to the tenuity of the walls in proportion to the size of the chambers.

The figured specimens, which are from Dr. Carpenter's collection, were obtained on the cruise of the "Valorous" in the North Atlantic, at about lat. 59° N., depth 1750 fathoms. The species also occurs at one of the "Porcupine" Stations, north-west of Ireland, 1380 fathoms. Of the Challenger specimens the best are from Station 168, east of New Zealand, 1100 fathoms. Three other Pacific localities, namely Stations 244, 246, and 271, depths 2900 fathoms, 2050 fathoms, and 2425 fathoms respectively, furnish examples more or less characteristic, and complete the record of its distribution

Ammodiscus, Reuss.

Operculina, pars, d'Orbigny [1839], Reuss, Pourtales, Brauns.
Orbis, Strickland [1848].
Spirillina, pars, Rupert Jones [1850], Williamson.
Trochammina, pars, Jones and Parker [1860], Carpenter, Brady, Karrer, Robertson, Norman, Siddall, Wright, &c.
Ammodiscus, Reuss [1861], Bornemann, Karrer, Berthelin, Brady, Siddall, Bütschli.
Cornuspira, pars, Reuss [1862], Karrer, Schwager, Terquem, Kübler and Zwingli.
Involutina, pars, Terquem [1862].
Serpula, Schmid [1867].

Test free, spiral; consisting of a non-septate tube, coiled regularly either on one plane, on an elongated axis, or in several tiers; or else with whorls irregular both as to outline and disposition. Texture finely arenaceous, surface smooth.

This generic or sub-generic group includes all the non-septate tubular *Trochammininæ*. In its typical condition the test is spiral; and the various subordinate forms differ from each other chiefly in the manner in which the convolutions are arranged. The tube itself is sometimes of nearly uniform diameter from end to end, but more frequently increases in width more or less with each convolution.

The genus *Ammodiscus* is represented in one form or other in almost every part of the world, and at every depth at which the sea-bottom has been explored, from the estuarine shallows of our own coast down to 3000 fathoms or more; and its geological history extends as far back as the earliest part of the Carboniferous epoch.

Ammodiscus incertus, d'Orbigny, sp. (Pl. XXXVIII. figs. 1–3).

Operculina incerta, d'Orbigny, 1839, Foram. Cuba, p. 71, pl. vi. figs. 16, 17.
Orbis infimus, Strickland, 1848, Quart. Journ. Geol. Soc., vol. ii. pl. xxx. fig. *a*.
Spirillina arenacea, Williamson, 1858, Rec. For. Gt. Br., p. 93, pl. vii. fig. 203.
Trochammina squamata incerta, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 304.
„ *incerta*, Carpenter, 1862, Introd. Foram., p. 141, pl. xi. fig. 2.
„ *squamata*, var. *incerta*, Parker and Jones, 1862, Ibid. Appendix, p. 312.
Involutina silicea, Terquem, 1862, Mém. Acad. imp. Metz, 1860–1, p. 450, pl. vi. fig. 11.
„ *aspera*, Id. 1863, Ibid. 1862–3, p. 221, pl. x. fig. 21.
Cornuspira hoernesi, Karrer, 1866, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lii. p. 495, pl. i. fig. 10.
Cornuspira oolithica, Schwager, 1867, In Waagen's Ueber die Zone des Amm. sowerbyi, vol. i. pt. iii. p. 655, pl. xxxiv. fig. 4.
Trochammina incerta, Brady, 1876, Monogr. Carb. and Perm. Foram., p. 71, pl. ii. figs. 10–14.
Ammodiscus miocenicus, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 372, pl. xvi. *a*., fig. 2.
Ammodiscus incertus, Berthelin, 1878, Foram. de Bourgneuf et Pornichet, p. 23, No. 17.
Trochammina incerta, Haeusler, 1882, Ann. and Mag. Nat. Hist., ser. 5, vol. x. p. 52, pl. iii. figs. 1–4.

Test spiral, discoidal, thin; peripheral edge rounded; consisting of numerous narrow convolutions on one plane of a non-septate tube of slightly increasing diameter. Aperture usually formed of the open unconstricted end of the tube. Texture very finely arenaceous, exterior smooth; colour (of recent specimens) ruddy brown. Diameter, $\frac{1}{100}$th to $\frac{1}{9}$th inch (0·25 to 2·8 mm.).

Owing to the very frequent occurrence of *Ammodiscus incertus* in the fossil condition, and to the extent of its geological range, few species of Foraminifera have been described under so many different names. Of these only the more important appear in the above synonymy, and a much longer list might easily be compiled.

In an organism so simple that the essential characters of the test may be summed up in half a dozen words—a smooth arenaceous planospiral tube—the points open to variation are necessarily few; in fact they are almost limited to the size of the disk, the diameter of the tube, the shape of its transverse section, and the number of convolutions; and all these are more or less dependent on one another.

The dimensions which have been given by no means represent the entire range in size, for the specimens originally described by d'Orbigny, from West Indian shore-sands, were only one-tenth of a millimetre in diameter. No doubt individuals as minute as this are occasionally found, but about 0·5 mm. is the average measurement of recent specimens, as found in very deep or very shallow water, and such shells generally consist of five or six convolutions of nearly even width. The exceptionally large specimens frequently met with in localities rich in arenaceous Foraminifera, at depths of from 300 to 1000 fathoms or thereabouts, attain a diameter of nearly 3 mm., and often present from fifteen to twenty convolutions. In these the early whorls are narrow, and there is a slow gradual increase in width, which is rather more rapid in the later stages. The successive convolutions are sometimes slightly embracing, and as the peripheral edge of the test is always rounded, the shape of the tube in transverse section depends a good deal upon the extent to which its sides overlap, and may be oval, circular, semicircular, or crescentiform.

Turning for a moment from the consideration of the characters of the recent test, the following note from the Monograph of Carboniferous and Permian Foraminifera, p. 73, apropos of the earliest fossil representatives of the species, may not be out of place :—"Wherever it (*Ammodiscus incertus*) exists as a palæozoic fossil it appears in large numbers, and the specimens present a correspondingly wide range of variation in minor characters. Many specimens are just such as might be dredged at the present day on our own shores, consisting of five or six convolutions in one plane of a non-septate tube, the convolutions nearly uniform in breadth, and the tube having an approximately circular transverse section. The examination of a large number of individuals reveals many little modifications of these simple typical characters. Sometimes the number of convolutions is smaller and their width greater, forming a test of similar diameter and without increase of thickness, and in such the tube presents a long oval instead of a circular transverse section. Other examples show a tendency in the successive convolutions each to embrace, to a limited degree, that immediately within it, and the section of the tube is then more or less crescentiform. In some of the larger complanate shells the spiral tube increases in width with each succeeding circlet. Lastly, it is not at all uncommon to find the shell-wall thickened, especially near the centre of the disc, the excavated sutural line filled up, and the test assuming thereby a more or less lenticular or biconvex figure. In these instances the calcareous cement is largely in excess of the arenaceous material, the surface of the test is nearly smooth, and even permits, by a sort of transparency, the course of the spiral cavity in the interior to be traced. These modifications, in addition to many irregularities in external contour, arise from what may be regarded as accidental circumstances, and present no ground for specific or varietal subdivision."

From this description it will be gathered that the *Ammodiscus incertus* of the Car-

boniferous epoch had just the same characters as its living descendants and similar limits of variation—the only difference being the tendency to shell-thickening occasionally exhibited in the fossil test, and the larger dimensions of some of the living specimens, both of which are exceptional features.

The area of the geographical distribution of *Ammodiscus incertus* does not include the polar seas, like that of its near ally *Ammodiscus gordialis;* nevertheless the species has been observed as far north as the southern coast of Norway and the Faröe Channel. It is found on the shores of Great Britain, Belgium, and France; and Parker and Jones report its occurrence at four points in the Mediterranean, at depths ranging from 90 to 360 fathoms. The Challenger gatherings furnish specimens from four Stations in the North Atlantic, 450 to 1350 fathoms; from four in the South Atlantic, 675 to 2350 fathoms; and from seven in the South Pacific, 275 to 2325 fathoms. The only record of its presence in the North Pacific is at a single point in the very deep area—Station 253, depth 3125 fathoms, and the specimens from that locality evince a tendency to become irregular in contour, like *Ammodiscus gordialis.*

Ammodiscus incertus is a common fossil of the Carboniferous beds of England and Scotland, and a rarer constituent of the *Fusulina* rocks of the Caucasus. In the Permian system it appears in the Lower and Middle Magnesian Limestones of England, and in the Zechstein of Germany. It is found in the Lias of England, France, and Germany, and in the Oolitic formations of England, France, and Switzerland; in the Cretaceous series of England, Germany, and Bohemia, in the Eocene Clays of the London Basin, and in the Lower Tertiary Sandstones of Vienna. The stratigraphical details of its distribution may be found, for the most part, in the memoirs referred to in the synonymy of the species.

Ammodiscus tenuis, H. B. Brady (Pl. XXXVIII. figs. 4–6).

Ammodiscus tenuis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 51.

Test circular, planospiral, very thin; consisting of a few broad somewhat overlapping convolutions; peripheral edge rounded. Diameter of large specimens, $\frac{1}{8}$th inch (3 mm.).

This is probably nothing more than a local variety of *Ammodiscus incertus*, to which it bears somewhat the same relation that *Cornuspira foliacea* bears to *Cornuspira involvens.* Nevertheless the comparison of small, possibly immature specimens of the two forms (figs. 2 and 4), is sufficient to show that the morphological distinction does not vary either with size or stage of growth. Adult examples of *Ammodiscus incertus* and *Ammodiscus tenuis* of about the same dimensions, present, the one about seventeen, the other about seven convolutions; and the test is altogether thinner in the latter variety.

Ammodiscus tenuis is of very restricted distribution, and the record of its occurrence

extends to only four Challenger Stations. The finest specimens, amongst them those from which figs. 5 and 6 have been drawn, are from Station 168, east of New Zealand, 1100 fathoms. The remaining localities are Station 46, off the North American coast, in about the latitude of New York, 1350 fathoms; off Kandavu, Fiji Islands, 210 fathoms; and off the west coast of Patagonia, 400 fathoms.

Ammodiscus gordialis, Jones and Parker, sp. (Pl. XXXVIII. figs. 7–9).

Trochammina squamata gordialis, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 304.
„ *gordialis*, Carpenter, 1862, Introd. Foram., p. 141, pl. xi. fig. 4.
„ *squamata*, var. *gordialis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 408, pl. xv. fig. 32.
„ *proteus* (pars), Karrer, 1866, Sitzungsb. d. k. Ak. Wiss. Wien, vol. liii. p. 494, pl. i. figs. 1–3.
Cornuspira variabilis (pars), Kübler and Zwingli, 1870, Foram. d. schweiz. Jura, p. 33, pl. iv. fig. 4, *b*.
Trochammina gordialis, Brady, 1876, Monogr. Carb. and Perm. Foram., p. 77, pl. iii. figs. 1–3.
Ammodiscus gordialis, Siddall, 1879, Catal. Brit. Rec. For., p. 5.
„ *gaultinus*, Berthelin, 1880, Mém. Soc. géol. France, sér. 3, vol. i. Mém. 5, p. 19, pl. i. fig. 3, *a.b*.
Trochammina gordialis, Haeusler, 1882, Ann. and Mag. Nat. Hist., ser. 5, vol. x. p. 55, pls. iii., iv. figs. 8–20.

Test convoluted, rounded, asymmetrical; composed of a tube of nearly even diameter coiled upon itself in an irregular manner, and in varying directions. The tube (in transverse section) variable in shape; sometimes twisted or even contracted at irregular intervals; aperture formed by the open end, sometimes slightly constricted, occasionally furnished with a thickened lip. Colour and shell-texture as in *Ammodiscus incertus*. Diameter, $\frac{1}{100}$th to $\frac{1}{30}$th inch (0·25 to 0·84 mm.) or more.

This species was designed by Parker and Jones to include the group of somewhat anomalous forms that, morphologically speaking, occupy the ground between the symmetrically constructed complanate type, *Ammodiscus incertus*, and the subglobular *Ammodiscus charoides*. The test is of intermediate size, and the tube is generally of nearly even diameter throughout. It is neither coiled on one plane nor in vertical tiers, but irregularly, a few convolutions in one direction and then a few in another, apparently without rule, the resulting test assuming either a rounded or compressed form.

Ammodiscus gordialis has been collected in the Arctic Sea as far north as the shores of Franz-Josef Land, lat. 79° to 80° N., at depths of 113 to 145 fathoms; off Novaya Zemlya, 55 to 219 fathoms; and off the Hunde Islands, Baffin's Bay, 60 to 70 fathoms. Its geographical distribution, apart from this northern area, and its geological range, are analogous to those of the closely allied *Ammodiscus incertus*. The furthest

point southwards to which it has been traced is off Christmas Harbour, Kerguelen Island, 120 fathoms. Notes have been made of its presence at twenty-seven Challenger Stations, of which ten are at depths of more than 2000 fathoms, and five others at more than 1000, the remainder ranging from 50 fathoms downwards.

In the fossil condition it has been found in the Carboniferous rocks of England, Scotland, and Belgium, and in the Permian Magnesian Limestones of the north of England. It is figured by Kübler and Zwingli and by Haeusler from the Jurassic beds of Switzerland, and by Karrer from the Early Tertiary Vienna Sandstones.

Ammodiscus charoides, Jones and Parker, sp. (Pl. XXXVIII. figs. 10–16).

Trochammina squamata charoides, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 304.
„ *charoides*, Carpenter, 1862, Introd. Foram., p. 141, pl. xi. fig. 3.
„ *proteus* (pars), Karrer, 1866 Sitzungsb. d. k. Ak. Wiss. Wien, vol. liii. p. 494, pl. i. fig 4.
Cornuspira reussi, var. *excentrica*, Reuss, 1870, Ibid., vol. lxii. p. 464.—Schlicht, 1870, Foram. Pietzpuhl, pl. xxxv. figs. 13–23.
Trochammina charoides, Siddall, 1878, Proc. Chester. Soc. Nat. Sci., pt. ii. p. 47.
Ammodiscus charoides, Berthelin, 1878, Foram. de Bourgneuf et Pornichet, p. 23, No. 18.
Trochammina charoides, Haeusler, 1882, Ann. and Mag. Nat. Hist., ser. 5, vol. x. p. 56, pl. iv. fig. 21.

Test free, spiral, rounded; subglobular or biconvex; consisting of a tube of nearly even diameter coiled regularly upon itself in a compact series of vertical layers, resembling externally the nucule of *Chara*. Colour brown, surface smooth and glossy. Aperture the open or slightly constricted end of the tube. Diameter, $\frac{1}{75}$th inch (0·34 mm.).

Ammodiscus charoides is of smaller dimensions than either of the two species previously described; its structural features also are somewhat more complicated, and will be better understood from the drawings than from verbal description. Morphologically speaking, it occupies an intermediate position connecting *Ammodiscus incertus* with *Ammodiscus shoneanus*, the former of these being flat and planospiral, the latter cylindrical and vertically spiral, whilst *Ammodiscus charoides* is subglobular, and the arrangement of its convolutions is to some extent both complanate and vertical.

Ammodiscus charoides is by no means a common species, though it is distributed over a very wide area, and presents an extensive bathymetrical range. It has been found in the Faröe Channel, 530 fathoms, in the estuary of the Dee (Siddall); on the shores of the Bay of Biscay (Berthelin), and at three Challenger Stations in the North Atlantic, 450 to 1750 fathoms. Parker and Jones record its occurrence in the Red Sea, and at seven localities in the Mediterranean, 90 to 1700 fathoms. It has been noticed at three Stations in the South Atlantic, 1900 to 2350 fathoms; also between the Cape of Good Hope and

Kerguelen Island, 1570 fathoms ; off Kerguelen, 120 fathoms; at five points in the South Pacific, 345 to 2425 fathoms ; and at two in the North Pacific, 50–150 fathoms and 2575 fathoms respectively.

The earliest geological appearance of the species is in the Jurassic beds of Canton Aargau, Switzerland (Haeusler). As a Tertiary fossil it is figured by Karrer in his memoir on the older Vienna Sandstones, and by von Schlicht in his work on the Septaria-clay of Pietzpuhl, in North Germany.

Ammodiscus shoneanus, Siddall (Pl. XXXVIII. figs. 17–19).

Trochammina shoneana, Siddall, 1878, Proc. Chester Soc. Nat. Sci., pt. 2, p. 46, figs. 1, 2.
Ammodiscus shoneanus, Id. 1879, Catal. Brit. Rec. For., p. 5.
„ „ Balkwill and Wright, 1882, Proc. R. Irish Acad., ser. 2, vol. iii. (Science), p. 546.

"Test spiral, subcylindrical, slightly tapering, narrow end rounded [or sometimes sharply conical]; composed of a single series of close convolutions of a non-septate tube on a linear axis. Sutural line more or less depressed externally. Aperture large, rounded; formed of the end of the tube, somewhat constricted. Texture finely arenaceous, colour light brown to rusty red. Length, $\frac{1}{100}$th [to $\frac{1}{50}$th] inch [0·25 to 0·5 mm.]."

"This form is closely allied to *Trochammina gordialis* and *Trochammina charoides*. It differs from the former in its elongate regular habit of growth, and from the latter in the extension of the convolutions lengthwise in single series, instead of their superposition in several layers."

With the exception of the few words in brackets, the foregoing description and remarks are quoted from Mr. Siddall's interesting paper on the Foraminifera of the River Dee (*loc. cit.*) In connection with the trifling additions which have been made to the text, it may be explained, that whilst the Challenger specimens agree in all important points with those from the British coast, many of them, especially such as are of large dimensions, have the inferior end of the test slightly swollen and pointed. The maximum size is set down in the original description as $\frac{1}{80}$th inch, but amongst specimens from the Southern Ocean $\frac{1}{50}$th inch is not an unusual length.

Ammodiscus shoneanus was first obtained from shallow water at Hilbre Island and Holywell, in the estuary of the Dee (Shone, Siddall), and has since been taken off Slieve League, South Donegal (Wright), and in Dublin Bay (Balkwill and Wright). The two Challenger Stations at which it has been found present considerable contrast to these in latitude and depth; they are, off Christmas Harbour, Kerguelen Island, 120 fathoms; and Station 238, in the very deepest part of the North Pacific, 3950 fathoms.

Ammodiscus spectabilis, H. B. Brady (Pl. XXXVIII. figs. 20–22).

Ammodiscus spectabilis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 51.

Test free; composed of a non-septate tube wound upon itself, not regularly and symmetrically, so as to retain a rectilinear contour (as in *Ammodiscus shoneanus*), but in curved or twisted fashion, so as to form an arcuate or subhelicoid test. Shell-wall very thin; exterior somewhat rough, interior smooth and polished. Longer diameter, $\frac{1}{5}$th inch (5 mm.) or more.

It has not been without considerable hesitation that this form has been allotted a place amongst non-septate *Trochammininæ*. In the general contour and arrangement of the test, it resembles such species as *Ammodiscus shoneanus* and *Ammodiscus gordialis*, and there is no other group of Foraminifera with which it appears to have any particular affinity. On the other hand, the organism is altogether larger than any of its congeners, and the test, though thin, is comparatively rough externally. There is perhaps no Foraminifer of similar dimensions of which the investment is so thin and fragile; it is in fact little more than a chitinous membrane sprinkled with sand, with just sufficient calcareous cement to prevent it collapsing on being dried.

The drawings of this species are from specimens in Dr. Carpenter's collection, obtained on the "Porcupine" Expedition,—North Atlantic, 358 fathoms. Some broken tests, which when living must have possessed similar characters, though they are now too much injured to be identified with certainty, have been picked out of dredged material from one of the Challenger Stations in the South Atlantic,—east of Buenos Ayres, 1900 fathoms. These scanty items are the extent of our knowledge of its distribution.

Trochammina, Parker and Jones

Nautilus, pars, Montagu [1808], Pennant, Turton.
Rotalina, pars, Williamson [1858], Alcock, Parfitt.
Trochammina, Parker and Jones [1859], Reuss, Carpenter, Brady, Karrer, Miller and Vanden Broeck, Schulze, Robertson, G. M. Dawson, Berthelin, Siddall, &c.
Rotalia, pars, Morris and Quekett [1860].

Test free or rarely adherent, convoluted; Rotaliform, nautiloid, or irregularly coiled, more or less distinctly segmented. Walls thin, composed of minute sand-grains, either incorporated by calcareous or other cement, or embedded in a chitinous membrane; exterior smooth, often glossy; interior smooth, rarely punctate or reticulate, never labyrinthic.

The generic term *Trochammina* in its restricted sense is employed for all the convoluted modifications of the type that are distinctly segmented; whether they are

bilaterally symmetrical, as in *Trochammina trullissata*, Rotaliform as in *Trochammina inflata*, trochoid as in *Trochammina squamata*, or altogether irregular as in *Trochammina conglobata*. They are, with but little exception, free-growing; if adherent, the test is complete, and not tent-like without a proper shell on its inferior side, as in *Webbina*.[1] The segmentation is generally as perfect as that of the hyaline types of Foraminifera. The walls of the test are thin, and smooth externally; usually the interior surface is also smooth, but sometimes it is punctate or otherwise superficially marked. The aperture is invariably simple and undivided, and commonly takes the form of an arched slit.

The genus is cosmopolitan, both in its geographical and bathymetrical relations, though the individual species have a tolerably well-defined range of depth. Its earliest appearance, geologically speaking, is in the Lower Lias; but in the fossil condition *Trochammina* (proper) occurs much less frequently than the non-septate type *Ammodiscus*, and the number of specimens hitherto found is comparatively small.

Trochammina squamata, Jones and Parker (Pl. XLI. fig. 3, *a.–c.*).

Trochammina squamata, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 304.
„ „ Carpenter, 1862, Introd. Foram., p. 141, pl. xi. fig. 1.
„ *proteus* (pars), Karrer, 1865, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lii. p. 494, pl. i. fig. 6.
„ *squamata*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 56.

Test free or adherent, trochoid, Rotaliform; consisting of about four convolutions, each composed of four or five chambers; superior face convex or subconical; inferior flat or slightly concave; aperture an arched slit near the margin of the final segment on its inferior side. Colour brown; surface smooth, not polished. Diameter, about $\frac{1}{30}$th inch (0·84 mm.).

In establishing the genus *Trochammina*, Parker and Jones employed the specific term "*squamata*" for the form which they supposed to embody the typical characters of the group, and it is somewhat unfortunate that any doubt should have existed as to the precise variety they had in view. The only published figures to which the name has been appended are those in their "North Atlantic" memoir.[2] I have long suspected that these drawings represent the species previously described by Williamson under the name *Rotalina ochracea*,[3] and a recent examination of the type-specimens of the latter, kindly lent by the author, has convinced me that the supposition is well founded. There is, however, an allied but quite distinct modification of the genus, for which the same

[1] I am not quite sure that this is invariably true of *Trochammina ochracea*; occasional specimens appear as though the test had grown tent-wise, like *Webbina*.

[2] *Phil. Trans.*, vol. clv., pl. xv. figs. 30, 31.

[3] Rec. For. Gt. Br., p. 55, pl. iv. fig. 112, pl. v. fig. 113.

name has often been used by Parker and Jones, and for this I propose to retain their specific designation. As compared with *Trochammina ochracea*, the species in question is larger and more conical, has fewer segments, usually four or five in the outermost convolution, and on the inferior surface they present a nearly triangular outline,—it furnishes, in point of fact, the links connecting *Trochammina* with *Valvulina*.

Trochammina ochracea, Williamson, sp., is a very minute form, seldom exceeding $\frac{1}{100}$th inch (0·25 mm.) in diameter; plano-convex and depressed in shape, and composed of a large number of segments, usually seven or eight in the peripheral whorl; the segments though small are very distinct, but not generally so regular as shown in Williamson's drawing of the upper surface of the test. On the inferior side the septal lines are "arcuate, flexuose, and very prominent." This species is not uncommon in the British seas.

Trochammina squamata, in the restricted sense, occurs on both the British and Irish coasts, and has also been obtained from dredgings at two points in the North Atlantic, west of Ireland, 110 and 173 fathoms respectively, and off Culebra Island, West Indies, 390 fathoms. It has been taken at the mouth of the Rio Plata, South America, 13 fathoms; and at five Stations in the South Pacific, 41 to 1100 fathoms.

One of the figures in Dr. Karrer's series of fossil *Trochammininæ* from the Early Tertiary Sandstones of Vienna belongs pretty certainly to this species; and from a manuscript list communicated by Dr. R. Haeusler I learn that it is found in almost every zone of the Jurassic formation of the Canton Aargau in Switzerland.

Trochammina inflata, Montagu, sp. (Pl. XLI. fig. 4, *a.–c.*).

Nautilus inflatus, Montagu, 1808, Test. Brit., Suppl., p. 81, pl. xviii. fig. 3.
Rotalina inflata, Williamson, 1858, Rec. For. Gt. Brit., p. 50, pl. iv. figs. 93, 94.
Rotalina (*Trochammina*) *inflata*, Parker and Jones, 1859, Ann. and Mag. Nat. Hist., ser. 3, vol. iv. p. 347, F.
Trochammina inflata, Carpenter, 1862, Introd. Foram., p. 141, pl. xi. fig. 5.
„ *squamata*, var. *inflata*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 310.
„ *inflata*, Brady, 1865, Nat. Hist. Trans. Northd. and Durham, vol. i. p. 95.
„ „ (?) Tate and Blake, 1876, Yorkshire Lias, p. 452, pl. xvii. fig. 18.

Test free; trochoid or convex, depressed, Rotaliform; consisting of about three convolutions, the outermost of which is formed of five or six very ventricose segments with deeply excavated septal lines. Inferior face somewhat concave, with sunken umbilicus; peripheral margin lobulated. Aperture small, arched; situate on the inferior side of the final segment, close to the previous convolution, a little within the periphery. Colour pale brown, the small primary segments much darker than the rest. Diameter, $\frac{1}{35}$th inch (0·7 mm.).

Trochammina inflata is easily recognised by its large inflated segments and by the dark colour of its central chambers. It is one of the few species of Foraminifera that survive removal to brackish water, though the altered life-conditions bring about a corresponding change in the characters of the investment. In specimens living on the sea-bed the sandy walls of the test are compact and firmly cemented; but those from brackish pools, whilst retaining the morphological characters of the type, have thinner walls, and the sand-grains are embedded in a chitinous envelope with scarcely any cementing material. The extreme modification in this direction is exemplified in *Trochammina macrescens*, in which the investment is a flexible membrane, with so little calcareous incrustation that it is scarcely altered by treatment with dilute acids.

Trochammina inflata occurs at intervals all round the British Islands. It frequents comparatively shallow water, and finds its way into estuaries and other brackish areas. It has been collected by M. Berthelin on the north-east shores of the Bay of Biscay, and Mr. Robertson's cabinet contains specimens from the south-east portion of the coast of Spain.

It is found in the Post-tertiary clay of the Fens near Peterborough (Parker), and of the north-east of Ireland (Wright). Dr. Haeusler reports its occurrence in various beds of Jurassic age in the Canton Aargau, Switzerland. Tate and Blake include the species in their list of fossils from the Lias of Yorkshire, but the single figure they give (*loc. cit.*), so far as it is distinctive at all, more nearly resembles *Trochammina squamata* than the present form.

Trochammina nitida, H. B. Brady (Pl. XLI. figs. 5, 6).

Trochammina nitida, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 52.
„ „ Id. 1881, Denkschr. d. k. Akad. Wiss. Wien, vol. xliii. p. 100, No. 25.

Test free, regular, Rotaliform, compressed; consisting of about three convolutions, the outermost of which has about nine segments. Superior face nearly flat; inferior convex, somewhat excavated at the umbilicus; peripheral edge rounded, only slightly depressed at the sutures; aperture a curved slit on the final segment, close to the margin of the previous convolution. Surface smooth, not polished; colour greyish-brown. Diameter, $\frac{1}{50}$th inch (0·5 mm.).

This is a comparatively rare species, but easily identified by the complanate superior surface of the test, and its even margin, as well as by the number and regularity of the chambers. It may be distinguished from its isomorph of the Lituoline series, *Haplophragmium nanum*, which is found in similar localities, by its more symmetrical contour and larger number of segments, and by the finer texture of its walls.

Trochammina nitida was found in the northernmost area explored on the Austro-

Hungarian North-Polar Expedition, off Franz-Josef Land, 113 fathoms, and amongst Capt. Markham's soundings in shallow water on the shores of Novaya Zemlya. The Rev. A. M. Norman has collected the species at two points near Bergen on the coast of Norway,—south of Bukken, 150 to 210 fathoms, and Oster Fiord, 50 to 200 fathoms. Finally, it has been noticed at three Challenger Stations; namely,—off Cape de Verde Islands, 1070 fathoms; off Nightingale Island, Tristan d'Acunha, 100 to 150 fathoms; and off Prince Edward Island, 50 to 100 fathoms.

Trochammina coronata, H. B. Brady (Pl. XL. figs. 10–12).

Trochammina coronata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 58, pl. v. fig. 15.

Test spiral, nautiloid, biconcave; composed of three to six convolutions, all more or less visible externally; peripheral edge rounded and lobulate; segments numerous, about six or seven in the final whorl, distinct, inflated. Aperture simple, situate on the face of the terminal segment, near its junction with the previous convolution. Colour buff to reddish-brown, surface smooth, not polished. Diameter, $\frac{1}{10}$th inch (2·5 mm.).

This handsome species differs from its congeners in size as well as in general contour. The larger specimens are fully one-tenth of an inch in diameter, and are coronate or biconcave in form. The chambers are few in number, tent-like, and more or less embracing, though the successive convolutions do not entirely conceal those immediately preceding them. The width of the spiral band increases with each turn, and the chambers of the final whorl are large and prominent as compared with those of the earlier convolutions. The texture of the test is uniformly very finely arenaceous and opaque, but the colour varies a good deal within certain limits, namely from creamy white to dark brown. Amongst previously described Foraminifera it is not easy to find any with characters approaching those of *Trochammina coronata*; perhaps the nearest is *Trochammina inflata*, but in that species the test is Rotaliform, that is to say, all the segments are more or less exposed on the superior face, whilst those of the last convolution only are visible on the inferior side,—a feature sufficiently distinct from the symmetrical nautiloid habit of the present form.

In geographical distribution *Trochammina coronata* is associated with its congeners *Trochammina conglobata*, *Trochammina lituiformis*, and *Trochammina proteus*. It has been found at two Stations in the North Atlantic,—off Sombrero Island, West Indies, 450 fathoms; and off Culebra Island, 390 fathoms; and at one in the South Atlantic,—off Pernambuco 675 fathoms. Rare specimens, presenting similar morphological characters, but of comparatively minute dimensions, have been met with in one of the deepest North Pacific soundings—Station 238, depth 3950 fathoms.

Trochammina proteus, Karrer (Pl. XL. figs. 1–3).

Trochammina proteus (pars), Karrer, 1866, Sitzungsb. d. k. Ak. Wiss. Wien, p. 494, pl. i. fig. 8.

Test free, spiral, subdiscoidal; consisting of a tube of somewhat irregular diameter, and more or less distinctly segmented, coiled on itself, the successive convolutions being nearly in the same plane. Aperture large, terminal, with thickened border. Diameter, $\frac{1}{20}$th inch (1·25 mm.).

Under the general name *Trochammina proteus*, Dr. Karrer has figured a large and interesting series of fossil *Trochammininæ*, from the Older Vienna Sandstones.[1] That the specimens which form the subject of his illustrations are all varieties of a single type, will not be questioned by anyone who has had the opportunity of examining similar series, whether recent or fossil, but several of the forms had previously received varietal names from Parker and Jones; for example,—figs. 1, 2, 3 (*loc. cit.*), may be referred to *Trochammina* (*Ammodiscus*) *gordialis;* fig. 4 to *Trochammina* (*Ammodiscus*) *charoides;* and fig. 6 to *Trochammina squamata*. Fig. 8, however, of the same plate, does not accord in minor characters with any of the forms enumerated, but represents a discoidal, planospiral, distinctly-segmented test; and I propose to retain Karrer's name in a restricted sense, associating it with these particular features.

In the living condition such specimens are very rare, nevertheless the Challenger collections furnish examples from four localities, namely :—off Culebra Island, West Indies, 390 fathoms; east coast of South America, off Pernambuco, 675 fathoms; South Pacific, Low Archipelago, 2350 fathoms, and off Sydney, 410 fathoms.

The fossil specimens already mentioned are from beds of Early Tertiary age in the Vienna Basin; and Haeusler gives a figure of the same variety from the Jurassic formation of Canton Aargau, Switzerland.[2]

Trochammina conglobata, n. sp. (Pl. XL. figs. 8, 9).

Test convoluted, subglobular; composed of an irregularly segmented tube, coiled upon itself in a constantly changing plane. Segments inflated, varying in size and contour. Aperture terminal, arched; with thickened or everted margin. Surface smooth; colour pale brown. Diameter about $\frac{1}{20}$th inch (1·25 mm.).

Little need be added to the foregoing description. The species is closely allied to *Trochammina coronata*, with which it is also associated in distribution; the chambers are of similar size and shape, but in *Trochammina conglobata* they are irregularly combined, so as to form a rounded mass, instead of being coiled on one plane.

[1] Ueber das Auftreten von Foraminiferen in den älteren Schichten des Wiener Sandsteins. *Sitzungsb. d. k. Ak. Wiss. Wien*, 1866, vol. lii., pl. i. figs. 1–8.

[2] *Ann. and Mag. Nat. Hist.*, 1882, ser. 5, vol. x., pl. iii. fig. 41.

Amongst Dr. Karrer's numerous drawings of *Trochammina proteus*,[1] there is one (fig. 7) that probably pertains to this variety.

Trochammina conglobata only occurs at two Challenger Stations :—off Sombrero Island, West Indies, 450 fathoms ; and off the coast of South America, near Pernambuco, 675 fathoms.

Trochammina lituiformis, H. B. Brady (Pl. XL. figs. 4–7).

Trochammina lituiformis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 59, pl. v. fig. 16.

Test free, crosier-shaped ; consisting of an irregularly septate or pseudo-septate tube, spiral at its commencement, subsequently linear. Segments irregular in size, subcylindrical or ventricose; sutures marked by external constrictions. Aperture simple, terminal. Surface smooth, colour light brown. Length sometimes $\frac{1}{7}$th inch (3·7 mm.).

In addition to the present species, there exist at least two other crosier-shaped modifications of the Trochammine type, namely, the Carboniferous *Trochammina centrifuga*, and the Permian *Trochammina filum;* but these are alike characterised by the absence of septa, both in the spiral and linear portions of the tests, and pertain rather to the *Ammodiscus* series than to *Trochammina* proper. They are also, both of them, of comparatively minute size. The specimens now described are of fine dimensions, though somewhat irregular in general contour and in septation. In colour and shell-texture they are precisely similar to *Trochammina coronata.*

Trochammina lituiformis has been found at three localities only :—Station 24, off Culebra Island, West Indies, 390 fathoms ; Station 76, off the Azores, 900 fathoms; and Station 120, coast of South America, off Pernambuco, 675 fathoms.

Trochammina trullissata, H. B. Brady (Pl. XL. figs. 13–16).

Trochammina trullissata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 56, pl. v. fig. 10, *a*, *b*., 11.

Test spiral, nautiloid ; compressed, lenticular, somewhat excavated at the umbilici ; composed of about three convolutions, the last of which often almost entirely encloses those preceding it ; peripheral edge acute or rounded. Segments numerous, about nine in the later convolutions ; the sutures marked externally by slightly excavated sinuate lines. Exterior smooth and glossy ; interior surface often punctate or reticulate ; colour brown. Aperture crescentiform ; situated on the face of the terminal chamber, close to the margin of the previous convolution. Diameter, $\frac{1}{20}$th inch (1·25 mm.).

[1] *Sitzungsb. d. k. Ak. Wiss. Wien*, p. 494, pl. i. figs. 1–8.

Trochammina trullissata is easily distinguished from any other species by its perfectly regular, nautiloid or Nonionine contour, the number of chambers in each whorl, the sigmoid sutural lines, and the polished brown exterior. In small specimens (fig. 14) the convolutions are somewhat less embracing than in those of larger size, the peripheral edge is rounded and more or less lobulated, and the test is of lighter hue.

In general conformation, it is not unlike *Cyclammina cancellata*, but differs widely from that species in point of size and internal structure. The inner surface of the test is often punctate, as shown in fig. 16, and sometimes even exhibits a slightly raised reticulation; but in every case these are mere superficial markings, and, though they may foreshadow in a rudimentary way the cancellated structure of some of the more complex types, they bear little actual resemblance to the tubulated growths that nearly obliterate the chamber-cavities of *Cyclammina*.

The first examples of this beautiful little shell that came under my notice were in the Rev. A. M. Norman's mountings from one of the "Valorous" dredgings in Davis Strait, depth 1750 fathoms, and this probably represents its northern geographical limit; its range in the southern hemisphere extends to Station 144, between the Cape of Good Hope and Kerguelen Island, about latitude 46° S. Its presence has been noted at twenty-five localities, pretty evenly scattered over the North and South Atlantic, the Southern Ocean, and North and South Pacific. Of these only five have depths of less than 1500 fathoms, and fifteen are above 2000 fathoms.

Trochammina ringens, H. B. Brady (Pl. XL. figs. 17, 18).

Trochammina ringens, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 57, pl. v. fig. 12, *a.b.*

Test nautiloid, oblong, compressed, biconvex; composed of few convolutions, of which the last entirely encloses those previously formed. Peripheral edge acute or slightly rounded, lobulate; septal lines curved, somewhat excavated. Segments large, four or five in each convolution, embracing. Colour brown, surface usually polished. Aperture an arcuate slit overhung by a slight swelling or prominence; situated on the face of the terminal chamber, near the margin of the previous convolution. Longer diameter, $\frac{1}{20}$th inch (1·25 mm.).

Trochammina ringens is nearly allied to *Trochammina trullissata*, but the points of distinction are easily recognised. It has only about half the number of segments in each convolution, and the final whorl completely encloses the earlier ones, instead of leaving the penultimate coil partly exposed at the centre: the general contour of the test is biconvex, there is little or no depression in the umbilical region, and the terminal segment is conspicuously large. In the colour, texture, and external condition of the walls, the

two forms are alike, but *Trochammina ringens* has no vestige of the punctation or reticulation of the inner surface of the shell that has been alluded to in the description of *Trochammina trullissata*.

Trochammina ringens is much rarer than the allied species, and its area of distribution does not appear to extend beyond the Atlantic. It was, I believe, first found by the Rev. A. M. Norman,[1] in one of the "Valorous" dredgings, at the entrance of Davis Strait, depth 1750 fathoms. Its occurrence has been noted at four points in mid-ocean in the North Atlantic, 1675 to 2750 fathoms, and at two points in the South Atlantic, 1900 and 2350 fathoms; from which it will be seen that it has not hitherto been met with on bottoms of less depth than 1600 fathoms.

Trochammina galeata, H. B. Brady (Pl. XL. figs. 19–23).

Trochammina galeata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 52.

Test nautiloid and symmetrical, subglobular or compressed, showing only three segments externally, of which the last-formed constitutes much more than half the visible shell. Aperture situated on the peripheral face of the final segment, near its junction with the antepenultimate; simple, often immediately below a projection of the shell-wall. Diameter, $\frac{1}{50}$th inch (0·5 mm.).

In many particulars this species resembles *Trochammina ringens*, but it is scarcely so large, and is relatively thicker; its few segments, and the disproportionate size and embracing contour of the latest, are sufficiently distinctive.

Trochammina galeata is a rare and somewhat inconspicuous form, only found at great depths in mid-ocean. Its distribution list includes eight Challenger Stations, of which three are in the North Atlantic, two in the South Atlantic, two in the South Pacific, and one in the North Pacific, the entire range of depth being from 1825 fathoms to 2750 fathoms.

Trochammina paucicloculata, H. B. Brady (Pl. XLI. figs. 1, 2).

Trochammina paucicloculata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 58, pl. v. figs. 13, 14.

Test ovoid, slightly compressed, obscurely spiral; composed of about two convolutions, the later of which almost entirely conceals the earlier one. Segments few, usually three in each convolution, inflated; sutures slightly constricted. Test thin, finely arenaceous, brown; exterior surface smooth, often polished; interior smooth. Aperture a curved slit

[1] Mentioned by Mr. Norman, in the "Valorous" Report (*Proc. Roy. Soc.*, 1876, vol. xxv. p. 213), as "very near to, if not identical with, *Globigerina arenaria*," a view which was abandoned after the examination of specimens of that species furnished by Dr. Karrer.

on the superior side at the inner margin of the last segment. Length, $\frac{1}{50}$th inch (0·5 mm.).

Though easily overlooked by reason of its minute size, *Trochammina pauciloculata* is a well-marked and interesting species. It is isomorphous with the genus *Allomorphina* of Reuss, the recent specimens of which are of even smaller dimensions; but it has the shell-texture characteristic of its own genus, whilst Reuss's type is hyaline and perforate. In its general plan of growth it closely resembles the Rotalians, notwithstanding its small number of segments, and their unsymmetrical disposition. The specimens, as a rule, are very uniform even in minor characters; some are a little longer and others proportionately rather more compactly built, as shown in the two figures, but they present scarcely any variation in more important particulars.

Trochammina pauciloculata has a wide area of distribution, though the number of individuals found in any one locality is seldom very large. Its preference for deep water is evidenced by the fact that out of twenty-two Stations fifteen have depths of more than 1000 fathoms. It has been taken at nine points in the North Atlantic, depth 173 to 2435 fathoms; at two in the South Atlantic, 675 and 1900 fathoms respectively; at eight in the South Pacific, 420 to 2425 fathoms; and at three in the North Pacific, 1850 to 3950 fathoms.

So far as at present known, the species does not occur in the fossil state.

Carterina, nov. gen.

Rotalia, Carter [1877].

Test resembling *Trochammina* in contour and texture, but furnished with calcareous spicules proper to itself.

The presence of spicules in the test of an arenaceous Foraminifer is so common an occurrence that under ordinary circumstances it attracts but little notice; many species in fact systematically employ the débris of siliceous sponges, generally in combination with siliceous sand, as building material. But a composite test in which calcareous spicules, to all appearance secreted by the animal inhabiting it, form a conspicuous element, is not only unusual, but marks an important structural deviation from anything otherwise known in this section of the Rhizopoda. Such an organism is that discovered by Mr. Carter, and described by him under the name *Rotalia spiculotesta*. But whilst its morphological features attest a close relationship to *Trochammina*, it is obvious that the presence of spicula, not collected from external sources for the construction of the test, but proper to the animal itself, is a character of more than specific significance. I therefore propose that it should bear the generic, or pending further research, the subgeneric name, *Carterina*.

Carterina spiculotesta, Carter, sp. (Pl. XLI. figs. 7–10).

Rotalia spiculotesta, Carter, 1877, Ann. and Mag. Nat. Hist., ser. 4, vol. xx. p. 470, pl. xvi.—*Ibid.*, 1879, ser. 5, vol. iii. p. 414.—*Ibid.*, 1880, ser. 5, vol. v. p. 452.

Test adherent, Rotaliform; superior surface convex or subconical, inferior flat or concave; outline lobulated or irregular; margin rounded, or thin and subangular. Composed of numerous convex segments, small at first and arranged in a Rotaliform spire, but subsequently becoming irregular in form and disposition. Walls thin and arenaceous; constructed for the most part of fusiform calcareous spicules embedded in calcareous cement. Surface nearly smooth; colour dark-brown near the centre, the subsequent whorls much lighter, and the outermost chambers often nearly white. Aperture indistinct; situated at the umbilical margin of the inferior side of the terminal chamber. Diameter, $\frac{1}{15}$th inch (1·6 mm.) or less.

Of the contour and general structure of this species little need be said beyond what is embodied in the foregoing zoological description. Small specimens are as a rule regularly trochoid and Rotaliform (fig. 8), and scarcely differ in shape from *Trochammina squamata*, but they invariably become less symmetrical as they increase in age. In very large examples, such as that represented in Mr. Carter's original drawing, the margin is thin, the later segments broad and spreading, and the outline deeply lobed and very irregular.

Generally speaking it is extremely difficult to detect the pseudopodial aperture; but in one specimen which has come under my notice it is tolerably distinct, and consists of a curved slit, placed at the umbilical edge of the inferior side of the last segment, and is partially hidden by a shelly flap. It probably therefore follows the same rule as to position and form as similar varieties of *Trochammina* and *Valvulina*.

The interest of the species, however, centres in the spicules, which are solid fusiform bodies with pointed ends; the larger ones, that is to say, the great majority of the whole, measuring pretty uniformly about $\frac{1}{360}$th inch (0·07 mm.) in length, with a diameter at the middle equal to $\frac{1}{4}$th or sometimes $\frac{1}{3}$rd of the length, the smaller ones being proportionately narrower. Their appearance, magnified 100 diameters, is given in figs. 9, 10. They are to be found in every stage of growth, but in the later segments of the mature test, those of maximum size predominate almost to the exclusion of the smaller ones. It is an interesting fact that the shape and dimensions of the spicules of specimens collected in the Red Sea correspond accurately with those described by Carter from tests collected in the South Sea Islands and the Gulf of Manaar. The spicules are calcareous, and they dissolve slowly in acids with effervescence. In the figured specimens (figs. 7, 8), so far as can be seen externally, they constitute almost the entire testaceous skeleton, but in one which has been broken in order to show the structure, the thicker portions of the

wall contain a certain amount of siliceous or calcareous sand, and the same condition has been observed by Carter in the earlier stages of the shell.

With respect to the general structure of the test, Mr. Carter has pointed out the "resemblance that exists between the spicular bodies and the scales of *Euglypha alveolata*, &c., among the fresh-water Rhizopoda, inasmuch as the 'scale,' like the spicular body, is formed by the *animal itself*, and subsequently cemented together by chitinous substance to form the test—thus differing from the tests of other Rhizopoda (where the particles are *foreign* and all of the same size) in being *proportioned in size* to that of the chamber which they respectively cover." The last clause of this quotation refers to the smaller size of the spicules in the earlier portions of the test. It may just be added that the cement appears to be in part at least calcareous.

The student of the Foraminifera accustomed to the spicular tests of *Marsipella*, *Haliphysema*, and *Pilulina*, will naturally ask how far it can be demonstrated that the spicules of *Carterina* are secreted by the animal itself, and are not extraneous bodies, selected as building material, in the same way as siliceous spicules are employed by the aforesaid genera. The following considerations bear upon this point:—there is no admixture of different sorts of spicules, as in the cases referred to, but they are all of the same form and character; there are no broken spicules, such as invariably exist in large proportion in the composite tests of other genera; in each test spicules are found in different stages of growth, and in the investment of the smaller chambers the spicules are of correspondingly smaller size; specimens of the organism obtained from areas very far apart, and under different external conditions, have spicules identical in size, shape, and composition; other arenaceous Foraminifera from the same localities have no spicula of similar character; and lastly, in no specimen of *Carterina* has any spicule been identified as pertaining to any particular species of sponge.

In connection with this subject, attention may be drawn to an interesting organism described by Mereschkowsky,[1] under the name *Wagnerella borealis*, and treated by him as a Sponge nearly allied to the *Physemaria* of Hæckel. In form and habit it resembles *Haliphysema;* and, in addition to the brush of spicules at the distal extremity, the chitinous peduncle has embedded in it numerous calcareous bodies of the same general character as the spicules of *Carterina*. Since the foraminiferal affinity of *Haliphysema* has been established, and the existence of calcareous spicula in the test of a well-defined type of Foraminifera has also been demonstrated, it would be interesting to know more of the actual structure of an animal, which, to judge by its investment, appears more or less related to both.

Of the distribution of *Carterina spiculotesta* little is known beyond the fact that it has been found attached to pieces of coral, nullipore, and the like, from the comparatively shallow water of tropical and subtropical seas. Mr. Carter's original specimen was from

[1] *Ann. and Mag. Nat. Hist.*, 1878, ser. 5, vol. i. p. 70, pl. vi.

the South Pacific, and he has more recently recorded the occurrence of the species in the Gulf of Manaar; those in my own cabinet are from dredgings taken by the late Mr. M'Andrew in the Gulf of Suez, at a depth of 40 fathoms.

Webbina, d'Orbigny.

Webbina, d'Orbigny [1839], Terquem, Brady, Robertson, Blake.
Trochammina, pars, Jones and Parker [1860], Carpenter, Brady, M. Sars.

Test adherent; consisting of a single, convex, tent-like chamber, or of several such chambers connected by stoloniferous tubes. Texture very finely arenaceous; surface smooth, often polished; colour, in recent specimens, reddish-brown.

M. Cornuel's interesting memoir on fossil microzoa from the Cretaceous beds of the Department of the Haute-Marne in France[1] contains excellent figures of two species of arenaceous Foraminifera, which were mistaken by the author for the ova of mollusca, and described accordingly. They represent, in point of fact, the typical forms of the adherent groups of the *Lituolinæ* and *Trochammininæ* respectively. Of one of them, *Placopsilina cenomana*, the description has already been given; the other, which received from d'Orbigny two names, *Webbina flexuosa* and *Webbina irregularis*,[2] may be accepted as the type of the subordinate group we have now to consider. The genus *Webbina* had been established some years previously for a recent species, *Webbina rugosa*;[3] but there is some doubt, to judge from the figure, whether the specimen on which it was founded was anything more than one of the rough adherent varieties of *Nubecularia;* and in any case Cornuel's drawings afford a safer basis for generic definition.

There are at least four well differentiated species or varieties of adherent *Trochammininæ*, namely:—1, *Webbina irregularis* (including *flexuosa*), which may be regarded as the type,—a moniliform shell with distinct, oval chambers, more or less separated by the stoloniferous tubes, rarely branching; 2, *Webbina alternans*, in which the segments are oval or pyriform, and the stolons issue from the two sides alternately, so that the shell has a somewhat Textularian character; 3, *Webbina clavata*, usually consisting of a single oval chamber with a long adherent tubular process, the open end of which forms the aperture; and 4, *Webbina hemisphærica*, of which the test is circular and convex and without any oral tube.[4] Of these species, only the third and fourth require more detailed notice.

In one form or other the genus *Webbina* is found living at every depth from about

[1] *Mém. Soc. Géol. France*, 1848, 2e sér., vol. iii. pl. iv. fig. 37.
[2] Prodrome de Paléontologie, 1850, vol. ii. p. 111, Nos. 782, 783.
[3] Foram. Canaries, 1839, p. 125, pl. i. figs. 16–18.—For. Foss. Vien., p. 74, pl. xxi. figs. 11, 12.
[4] *Vide*—Monogr. Crag Foram., 1866, pt. i. p. 25.

30 fathoms to 1900 fathoms; and fossil specimens appear at almost every geological age from the beginning of the Liassic period to the present time.

Webbina clavata, Jones and Parker (Pl. XLI. figs. 12–16).

Trochammina irregularis clavata, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 304.
„ *irregularis* (pars), Carpenter, 1862, Introd. Foram., p. 142, pl. xi. fig. 6.
Webbina irregularis clavata, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 26, No. 3.
„ *clavata*, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 711.

Test consisting typically of an oval or pyriform, convex, tent-like chamber, with a tube of indefinite length issuing from the narrow end; both chamber and tube adherent, the open extremity of the latter serving as the aperture. Shell-wall finely arenaceous, smooth and glossy externally, of rich reddish-brown colour. Longer diameter of the chamber, from $\frac{1}{50}$th to $\frac{1}{25}$th inch (0·5 to 1·0 mm.).

Apart from its ruddy-brown colour and polished surface, which are very distinctive features, the tent-like construction of the test of *Webbina clavata* is its most important and most easily recognised character. The only organism with which the species is likely to be confounded is *Hyperammina vagans*. These two forms resemble each other to the extent that both are parasitic, and that they consist alike of a chamber with a tube of indefinite length issuing from it; but in *Hyperammina* both chamber and tube are complete in themselves and invest the animal on all sides; whilst in *Webbina* the chamber is only a patelloid tent, and the tube semicylindrical, so that the test, which has no wall of its own on the inferior side, is closed-in by the surface of the body to which it is adherent.

The tubular portion grows to an indefinite length, but under all circumstances retains its semicylindrical adherent condition, and, in the absence of larger objects, attaches itself to *Globigerinæ* or other bodies of microscopical dimensions, as seen in fig. 16.

In some instances, in addition to the tubulated orifice, a small aperture may be detected in the convex face of the chamber, (fig. 14), but this is comparatively rare; and occasionally the detached test exhibits a minute aperture on the inferior edge, at the broader end, as appears in fig. 15.

In localities at which the species abounds the tests are often thrown together in colonies, several individuals overlying one another. An example of this sort is depicted in fig. 13, and an even larger number of chambers may sometimes be found piled together the same way.

The geographical distribution of *Webbina clavata* extends over a very large area, and its bathymetrical range includes every depth from about 100 to nearly 2000 fathoms, the finest specimens being found at less than 1000 fathoms. It is common in the

North Atlantic, from the coast of Norway and the Faröe Channel to the west of Ireland, the Azores, the Danish West Indies, the Cape de Verde Islands, and southwards to the equator. In the South Atlantic it has been collected at four Stations, between Pernambuco and the Falkland Islands; it occurs at two Stations between the Cape of Good Hope and Kerguelen Island, and at seven in the South Pacific. It is a somewhat curious fact that, though it is found in the South Pacific to within about two degrees of the equator (Station 218), not a single specimen has been met with in any of the North Pacific dredgings. Parker and Jones record the occurrence of the species at eight localities in the Mediterranean, at depths varying from 90 to 1700 fathoms. It is not known in the fossil condition.

Webbina hemisphærica, Jones, Parker, and Brady (Pl. XLI. fig. 11).

Webbina hemisphærica, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 27, pl. iv. fig. 5.
„ „ Robertson, 1875, Report. Brit. Assoc., Bristol Meeting, p. 189.

Test adherent, monothalamous; circular in outline, convex or subconical; presenting no visible aperture; walls finely arenaceous, smooth externally; colour dirty-white to reddish-brown. Diameter, $\frac{1}{50}$th to $\frac{1}{18}$th inch (0·5 to 1·4 mm.).

There is little to be said about this very simple organism. Its contour is that of a low bell-tent, and it has no conspicuous orifice, the sarcode presumably finding its outlet between the rim of the test and the object upon which it is parasitic.

The specimen originally described was found amongst other fossil microzoa from the Crag of Sutton; and no other locality was known for the species until it was dredged in the living state, in 1874, by Dr. G. S. Brady and Mr. Robertson, at two points on the coast of Durham, namely:—seven miles off Marsden, 33 fathoms; and five miles off Red Cliff, 25 to 30 fathoms. Apart from doubtful specimens, these particulars comprise what is known of its distribution.

Sub-family 3. Endothyrinæ.

This Sub-family is composed exclusively of fossil species.

Sub-family 4. Loftusinæ.

Cyclammina, H. B. Brady.

Lituola, pars, Carpenter [1870], Carter.
Cyclammina, Brady [1876], Norman, Carpenter.

Test free, convoluted; lenticular, discoidal, or subglobular; composed of numerous segments arranged in a nearly symmetrical nautiloid spire, the final convolution com-

pletely enclosing those previously formed. Walls thick, finely arenaceous, cancellated; sometimes developed to such an extent as to obliterate the early chamber-cavities and to lessen materially the size of the later ones; smooth externally. Aperture a curved fissure, sometimes supplemented by a number of pores on the face of the terminal chamber.

The genus *Cyclammina* represents the highest development of the arenaceous type of structure amongst living Foraminifera. Its characteristic feature, that in which it differs from all other recent nautiloid forms, is the peculiar labyrinthic condition of the skeleton. This may be best studied in the typical *Cyclammina cancellata*, not only on account of the larger dimensions of the specimens and their comparative abundance, but also because in that species the cancellated structure attains its fullest proportions.

The genus has a wide geographical distribution, affecting depths of from 100 to 2900 fathoms. It is not known in the fossil state.

Cyclammina cancellata, H. B. Brady (Pl. XXXVII. figs. 8–16).

"Nautiloid *Lituola*," Carpenter, 1875, The Microscope, 5th ed., p. 536, fig. 274, *a.b.c.*
Cyclammina cancellata (Brady, MS.), Norman, 1876, Proc. Roy. Soc., vol. xxv p. 214.
Lituola canariensis, Carter, 1877, Ann. and Mag. Nat. Hist., ser. 4, vol. xix. p. 203, pl. xiii. figs. 26–29.
Cyclammina cancellata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 62.
" " Carpenter, 1881, The Microscope, 6th ed., p. 564, fig. 322, *a.b.c.*

Test nautiloid, biconvex, depressed at the umbilici; margin even or slightly lobulated; peripheral edge rounded or subangular: composed of from two to three convolutions, the latest of which almost or completely encloses that preceding it. Segments numerous, ten to sixteen in the last convolution; narrow, marked externally by sinuate, slightly excavated lines radiating from the umbilici. Chambers labyrinthic; the cavities almost or sometimes entirely occupied by the extraordinary development of the cancellated finely arenaceous walls. Exterior surface smooth and imperforate, except where abraded; colour, various shades of brown. Aperture, a crescentiform fissure, situated at the edge of the final segment, close to its union with the previous convolution; often supplemented by a number of large pores irregularly disposed on the face of the terminal chamber. Size variable; diameter sometimes as much as $\frac{1}{4}$th inch (6·3 mm.).

The typical *Cyclammina cancellata* is a large, compressed, nautiloid Foraminifer, with round peripheral edge; of brown colour and smooth exterior. The entire test is arenaceous, and it is conspicuous amongst allied recent forms by its relatively fine dimensions. As a rule the test is completely involute, but in some exceptionally large specimens (fig. 8) the final convolution leaves the penultimate partially exposed near the centre. In the normal

condition the spire is quite regular and on a uniform plane, but sometimes the test exhibits a certain amount of lateral asymmetry, as seen in figs. 8 *b*., and 11.

If the test be laid open horizontally, so as show the interior, it is found to consist of two to three convolutions of a gradually widening spire, regularly divided into chambers, as indicated by the sutural lines on the exterior. Fig. 12 represents a specimen so prepared, and fig. 14 a thin horizontal section viewed by transmitted light. The communication between the consecutive chambers is maintained by means of a curved slit-like orifice at the inner margin of each septum.

But the most striking peculiarity revealed by the sectional view is the extraordinary development of the testaceous skeleton. Instead of a simple external wall of ordinary thickness and septa to correspond, the parietes are developed to such an extent that no cavities whatever are apparent in the earlier chambers, and in those of the final convolution the open spaces are relatively very small, so that in point of fact almost the entire test is occupied by the walls.

As has been already stated, the walls are arenaceous, and composed of fine siliceous grains incorporated by a ferruginous cement. A thin layer on the exterior is solid and imperforate, as shown in fig. 13 ; but with this exception the entire substance, both of the outer wall and the septa, is cancellated, that is to say, it is perforated with tubular passages to such an extent as to present a porous spongy appearance. These passages are not mere accidental lacunæ, but are regularly constructed, and the sand-grains surrounding them are arranged and cemented in orderly fashion.

The only external indication of the interior structure of the test is to be found in the characters of the exposed septal face of the terminal segment of a growing specimen, such as that portrayed in fig. 11. In this figure the broad outer arch on the front of the last chamber represents the thickness of the shell-wall, and its nearly parallel tubulation is quite apparent, though better shown in the transparent section (fig. 14). The smaller area enclosed within this is the septum, the cancellated or tubulated structure of which appears externally in the form of irregularly disposed orifices.

Fig. 16 is taken from a specimen from which a small portion of the external imperforate coating has been artificially removed, in order to show the ends of the tubular passages lying immediately beneath. Old and worn shells, and even some that are otherwise perfect, are occasionally found abraded in this way, and might easily lead to the supposition that the test in its normal state is perforate, which is not the case.

Of the chemical composition of the test it need only be stated here that about 80 per cent. of the entire weight is silica, and nearly 9 per cent. peroxide of iron ; so that there can be little doubt that the latter body enters largely into the composition of the cement by means of which the sand-grains are incorporated.

It may be added that sand-grains of large size are sometimes employed in the con-

struction of the test (fig. 10), but the masonry is so neatly executed that they scarcely interfere with the smoothness and finish of the exterior.

The geographical distribution of *Cyclammina cancellata* embraces a very wide area, and its bathymetrical range extends from 75 fathoms to 2900 fathoms, though it cannot be said to flourish at depths of less than 250 or more than 1000 fathoms. The list of localities includes about twenty Stations in the North Atlantic, 75 to 2675 fathoms; one in the Mediterranean, 1200 fathoms; four in the South Atlantic, 100 to 1990 fathoms; six in the South Pacific, 147 to 1100 fathoms; and two in the North Pacific, one at 2900 fathoms, the other in the Japanese Seas, depth unknown.

Cyclammina orbicularis, H. B. Brady (Pl. XXXVII. figs. 17–19).

Cyclammina orbicularis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 53.

Test subglobular or slightly compressed, more or less excavated at the umbilici; consisting of less than two complete convolutions, the outer one, composed of eleven or twelve segments, alone being visible externally; sutures distinct, sometimes a good deal depressed. Walls thick; labyrinthic structure well developed. Aperture an arched slit at the inner edge of the terminal segment. Colour, various shades of grey and brown; surface smooth and glossy. Diameter, $\frac{1}{14}$th inch (1·8 mm.).

This is a subglobular modification, of smaller dimensions than the type, but otherwise bearing about the same morphological relation to it that *Nonionina pompilioides* bears to *Nonionina depressula*. Occasionally the segments are inflated and irregular, as shown in fig. 19, but more commonly the sutures are marked by regular lines very slightly excavated. The test is often of beautiful grey hue, and the surface of living specimens highly polished.

The finest specimens of *Cyclammina orbicularis* are those from Station 323, South Atlantic, east of Buenos Ayres, 1900 fathoms; but the species has also been found at Station 153, off the Antarctic Ice-barrier, depth 1675 fathoms; and at Station 168, east coast of New Zealand, 1100 fathoms.

Cyclammina pusilla, H. B. Brady (Pl. XXXVII. figs. 20–23).

Cyclammina pusilla, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 53.

Test lenticular, the two lateral faces equally convex, depressed at the umbilici; peripheral edge sharp, slightly lobulated; consisting of three convolutions, the last of which has about fifteen segments. Sutural lines depressed, often curved backwards near the periphery. Walls comparatively thin, the inner surface and septa labyrinthic. Diameter about $\frac{1}{25}$th inch (1 mm.).

Cyclammina pusilla is a dwarf modification of the typical form. It only attains about one-fourth the diameter of fully grown specimens of *Cyclammina cancellata*, yet the test consists of as many convolutions, and the number of chambers in each whorl is as large, or sometimes even larger. The thickness of the cancellated walls varies a good deal; sometimes, as in the figured specimen, they are very thin and uniform, and the labyrinthic structure amounts to little more than a roughening or reticulation of the interior surface. In this condition *Cyclammina pusilla* furnishes a connecting link with the genus *Trochammina*, one species of which (*Trochammina trullissata*) exhibits a similar internal reticulation of the lateral walls, though the septa retain their normal compact texture.

Cyclammina pusilla occurs in company with *Cyclammina orbicularis* at Station 323, South Atlantic, east of Buenos Ayres, 1900 fathoms; and Station 153, Antarctic Ice-barrier, 1675 fathoms.

Family V. TEXTULARIDÆ.

The Textularidæ constitute a large and very varied group of Foraminifera, but one in which the inter-relationship of the constituent types is easily traced.

The test in its typical condition is represented by an elongated spire, with only a small number of segments, usually two or three, in each convolution; and the numerous and diverse modifications which the series includes, are all referrible, in one way or other, to this primitive structure.

A tendency to produce dimorphous varieties is manifested in every section of the group; and when this takes place the change in the mode of growth is invariably from a more complex to a simpler arrangement of the parts. For example, a dimorphous test of which the earlier portion is arranged on the triserial plan finishes with a biserial or uniserial line of segments; one with biserial commencement has the later segments in a single row, and so on.

In the Sub-family Textularinæ the convolutions are, as a rule, either binary or ternary, that is to say, the chambers are arranged in either two or three opposed and alternating rows; and the division into genera is based upon the external conformation of the test and the nature of the general aperture. The true *Textulariæ* are distinctly biserial, and the normal orifice is an arched slit at the inferior umbilical margin of the final segment, the latter feature being open to some variation. The genus *Cuneolina* has likewise a biserial test, but it is flattened in the opposite direction, morphologically speaking, to that usual amongst the *Textulariæ*, the plane of compression being parallel to the plane of union between the two series of chambers. The genera *Verneuilina*, *Tritaxia*, *Chrysalidina*, and *Valvulina* are all normally triquetrous, and the first three are distinguished by their respective apertures, that of *Verneuilina* being Textularian in shape

and position, that of *Tritaxia* terminal and rounded, and that of *Chrysalidina* porous. *Valvulina*, in like manner, may be recognised by its aperture, which is an arched fissure partially closed by a valvular tongue; but it also differs from the allied forms in the disposition of its segments as well as in other particulars. The genera *Bigenerina*, *Spiroplecta*, *Gaudryina*, and *Clavulina* represent dimorphous types, closely related in one way or other to those already enumerated. *Pavonina*, though irregularly dimorphous in its mode of growth, stands somewhat apart, there being no corresponding monomorphous type to which it can be referred. The minute structure of the test in the TEXTULARINÆ displays greater variety than in almost any other group of Foraminifera of similar extent. In some species the shell-wall is thin, calcareous, transparent, and perforate, whilst in others it is coarsely arenaceous, and rough externally; and, between these extremes, almost every variety of texture may be met with. Superficial ornament of any sort is of comparatively rare occurrence.

In the Sub-family BULIMININÆ the typical plan of structure is that of a more or less elongated spire, with three or more segments in each convolution; but this becomes simplified in the weaker modifications. The genus *Bulimina* has spiral test of the typical description, but in *Virgulina* the whorls are irregular and few-chambered, and in *Bolivina* the segments take a definitely biserial arrangement. These forms have their dimorphous representative in the genus *Bifarina*. *Pleurostomella* differs from *Bolivina* chiefly in the character of the orifice. The normal aperture of the BULIMININÆ is a comma-shaped slit or loop, set obliquely on the inner face of the terminal segment; and the various forms which it assumes may generally be recognised as modifications of that typical condition. In all the recent BULIMININÆ the shell-wall is hyaline and perforate, and in certain species it is ornamented externally with longitudinal striæ or costæ, or with sharp spines. The texture of many of the larger fossil forms is subarenaceous, though the test retains its perforate character, and is seldom coarsely rugose externally.

The Sub-family CASSIDULININÆ constitutes an essentially biserial group. The primary arrangement of the segments is that of *Textularia*, or rather, having reference to the nature of the aperture, of *Bolivina;* but in the typical condition the structure is complicated by the helicoid mode of growth,—the biserial line of segments being partially folded lengthwise, and then coiled upon itself from the primordial end. In the genus *Cassidulina* the test is either convoluted and involute throughout, or the later portion is projected in a straight or curved line. In *Ehrenbergina* the shell is unfolded and unrolled almost from the beginning, and so furnishes the connecting link between *Cassidulina* and the biscrial BULIMININÆ. In *Orthoplecta* the segments are combined in an irregularly alternating or spiral series, and form a cylindrical test without helicoid commencement. The aperture in the CASSIDULININÆ resembles in all respects that of the BULIMININÆ. The minute structure of the investment, whether in recent or

fossil species, is uniformly calcareous, hyaline, and perforate; and excepting in certain varieties of *Ehrenbergina*, which are more or less beset with spines, the shell is free from external ornament or exostoses of any kind.

Sub-family 1. Textularinæ.

Textularia,[1] Defrance.

Polymorpha, pars, Soldani [1791].
Textularia, Defrance [1824], Blainville, d'Orbigny, Römer, Reuss, Costa, Parker and Jones, Egger, Williamson, Terquem, Karrer, Carpenter, Seguenza, Berthelin, Terrigi, &c.
Textilaria, Ehrenberg [1839], Reuss, Stache, Karrer, Gümbel, Terquem, Schwager, Hantken, Moebius, &c.
Grammostomum, pars, Ehrenberg [1839], Kübler and Zwingli.
Proroporus, Ehrenberg [1844], Reuss.
Polymorphina, pars, Ehrenberg [1854].
Rhynchopleura (?), Ehrenberg [1856].
Plecanium, Reuss [1861], Karrer, Stache, Schwager, Gümbel, Hantken, Seguenza, Mártonfi.
Textillaria, Schwager [1865], Martonfi.
Cribrostomum, pars, Möller [1879].

The typical Textularian test consists of two rows of superimposed segments placed side by side, the segments of one row alternating with those of the other, and each segment communicating with that immediately preceding and that immediately following it, in the opposite row. The normal aperture is a transverse arched fissure at the inner margin of the terminal segment, close to its line of union with the penultimate. In exceptional cases the opening is surrounded by a raised lip or border; and specimens are also occasionally met with in which the later chambers have a small rounded terminal orifice, or even a number of pores scattered irregularly over the distal face, instead of the typical aperture.

In the smaller species of *Textularia* the shell-wall is usually hyaline and perforate; in the larger varieties the test either remains calcareous and becomes thick and opaque, or it puts on an external coat of siliceous sand; whilst some few species are entirely arenaceous, and resemble in structure the coarser *Lituolidæ*. Superficial ornament of any sort is very rare amongst the *Textulariæ*. Sometimes the sutures are marked externally by raised lines of shell-substance, and marginal or terminal spines are occasionally met with; but, apart from these, the only true surface-ornament is in the case of two or three species which have either fine longitudinal striæ or incomplete rounded costæ.

The geographical distribution of the genus *Textularia* is world-wide; living specimens

[1] I prefer to retain the generic term in its original form, notwithstanding the criticism to which it has been subjected. The question is not whether *Textilaria* is a more elegant adaptation from the Latin than *Textularia*, or whether *Texturina*, as has been suggested, might not be better than either, but simply one of authority and precedence.

are found in every sea and at almost every depth hitherto explored. Its geological range is correspondingly extensive, for it is not only one of the earliest known types of fossil Foraminifera, but one of the most abundant, occurring in nearly every microzoic deposit of marine origin from the Lower Carboniferous Limestones to the present time.

Textularia folium, Parker and Jones (Pl. XLII. figs. 1–5).

Textularia folium, Parker and Jones, 1865, Phil. Trans., vol. clv. pp. 370, 420, pl. xviii. figs. 19.
„ „ Moebius, 1880, Foram. Mauritius, p. 92, pl. viii. figs. 16, 17.

This species has been studied by Parker and Jones and by Moebius, and little need be added to the account they have furnished of its structural features. By the former authors it is described in its external aspect (*op. cit.*, p. 420), as "a very thin *Textularia*, with linear chambers, usually very unequal in their length, and forming a flat, pectinated, irregularly triangular or subrhomboidal shell."

Double specimens, such as that represented in Pl. XLII. fig. 5, are not uncommon. Prof. Moebius, who gives excellent figures of the species drawn on a somewhat large scale, remarks that out of sixteen specimens which he had obtained from the intestines of a *Maretia planulata*, four were in the double condition. He also states that, in each of the four, the larger shell of the pair had twice as many segments as the smaller one. This, however, is not an invariable rule, as may be seen by the example represented in Pl. XLII. fig. 5, which was selected without reference to the feature in question.

It is suggested by the same author that the union of two shells in the manner described may perhaps be due to sexual conjugation. But a similar phenomenon is very common in certain species of *Discorbina*, and I am disposed to regard it in either case as identical with a process that has been observed in some other Rhizopoda, the origin and history of which have been very satisfactorily traced by Gruber in connection with *Euglypha alveolata*;[1] namely, the production of a new individual by the gradual extension of a mass of protoplasm beyond the mouth of the parent test, and the subsequent division of the nucleus, an investing shell being formed as growth proceeds.

The following is a list of the localities at which *Textularia folium* has been observed:—off East Moncœur Island, Bass Strait, 38 fathoms; off Raine Island, Torres Strait, 155 fathoms; off Kandavu, Fiji, 255 fathoms; off Levuka, Fiji; Nares Harbour, Admiralty Islands, 17 fathoms; Honolulu Coral-reefs, 40 fathoms;—shore-sand, Melbourne (Parker and Jones); Mauritius (Moebius).

Textularia inconspicua, n. sp. (Pl. XLII. fig. 6, *a.b.c.*).

Test short, subconical, compressed laterally; distal end broadly elliptical, truncate or somewhat concave; apex rounded. Segments few, about six in each series, placed

[1] "Der Theilungsvorgang bei Euglypha alveolata." *Jenaische Zeitschr.*, 1881, vol. xxxv. p. 431, pl. xxiii.

transversely; sutures flush externally. Walls thin, hyaline, perforate. Length, $\frac{1}{100}$th inch (0·25 mm.).

This is a very minute and delicate species, with clear shell and rounded outline, often bearing considerable resemblance to a small trochoid Rotalian.

It is, moreover, exceedingly rare, and hitherto has only been noticed at three Challenger Stations, all in the Pacific, namely:—off East Moncœur Island, Bass Straits, 38 fathoms; Nares Harbour, Admiralty Islands, 17 fathoms; and the *Hyalonema*-ground south of Japan, 345 fathoms.

Textularia jugosa, n. sp. (Pl. XLII. fig. 7, *a.b.*).

Test oblong, tapering, compressed; oral end elliptical, truncate; aboral extremity subangular or rounded. Segments numerous, 6 to 10 in each series; sutures marked externally by stout raised bands of clear shell-substance. Length, $\frac{1}{50}$th inch (0·5 mm.).

D'Orbigny has figured a specimen to all appearance belonging to this species (Foram. Canaries, pl. i. figs. 19–21), under the name *Textularia sagittula;* and it is difficult to account for the apparent confusion of two forms so entirely distinct. *Textularia jugosa* is a well-marked species, but from its minute size, specimens may easily be overlooked amongst other Foraminifera.

It has only been observed at one Challenger Station, off Raine Island, Torres Strait, 155 fathoms, and in that locality the shells seldom attain a length of more than $\frac{1}{90}$th inch (0·3 mm.). Its occurrence has been noted in the Gulf of Suez, 15 to 20 fathoms; in Curteis Strait, Queensland; and in shore-sand obtained on the east coast of Madagascar; in the last-named district the examples are numerous and of comparatively large dimensions.

Textularia quadrilatera, Schwager (Pl. XLII. figs. 8–12).

> *Textilaria quadrilatera*, Schwager, 1866, Novara-Exped., Geol. Theil., vol. ii. p. 253, pl. vii. fig. 103.

This striking form is excellently figured by Schwager in his memoir on fossil Foraminifera from Kar Nicobar. It has a long, slender, tapering test, often terminating in a stout spine, compressed and quadrilateral, the four angles frequently carinate, and the walls hyaline and generally distinctly perforate. The shape of the aperture varies a good deal, and in the majority of recent specimens it resembles that of *Bolivina* rather than *Textularia;* but in many cases it has the simple arched character shown in the original figure, and I have therefore left the generic position of the species unaltered.

The average size of recent specimens somewhat exceeds that of the fossils, adult shells being seldom less than 1 mm. in length, and occasionally 1·2 mm., or even more.

Textularia quadrilatera has been observed at two Stations in the North Atlantic:—off Gomera, Canaries, 620 fathoms; and off St. Vincent, Cape de Verde Islands, 1070 fathoms; and at one in the South Atlantic,—south-east of Pernambuco, 350 fathoms. In the South Pacific it is more plentiful, having been found at eight localities, ranging in depth (with one exception) between 410 and 1350 fathoms. The finest examples were obtained off Tahiti, 420 fathoms.

The only recorded fossil specimens are those described by Dr. Schwager from the Pliocene of Kar Nicobar.

Textularia crispata, n. sp. (Pl. CXIII. fig. 2, *a.b.*).

Test free; elongate, tapering, complanate, always more or less twisted in contour; lateral faces flattened, peripheral edges square. Segments numerous, nine to twelve in each series, the marginal ends angular and projecting; sutures distinct, often slightly limbate. Walls thin, calcareous, or very finely arenaceous; colour white to light brown. Length, $\frac{1}{30}$th inch (0·84 mm.).

This is an exceedingly striking species, resembling *Textularia concava* and *Textularia quadrilatera* in its complanate form and square edges, but easily recognised by the twisted contour and the dentate lateral margins of the test.

Textularia crispata has only been found at a single locality, Station 185, off Raine Island, Torres Strait, 155 fathoms, where it is tolerably common.

Textularia transversaria, n. sp. (Pl. CXIII. figs. 3-5)

Test free; complanate, elongate, tapering; oral end broad and truncate, aboral extremity obtusely pointed or slightly rounded; lateral edges thin and irregular, or square. Segments numerous, ten to fourteen in each row, narrow; arranged transversely to the axis of the test; peripheral ends generally fistulose. Length, about $\frac{1}{50}$th inch (0·5 mm.).

It is possible that this may be only a fistulose variety of *Textularia pectinata*, Reuss (Denkschr. d. k. Ak. Wiss., vol. i. p. 381, pl. xlix. figs. 2, 3.—Sitzungsb. d. k. Ak. Wiss., vol. lv. p. 98, pl. iii. fig. 11), but in the absence of recent specimens exhibiting satisfactorily the normal characters of that species, there is nothing to indicate with certainty that such is the case.

The fistulose condition of the Textularian test is a subject of some interest, but will be better treated in connection with *Textularia siphonifera* and *Textularia sagittula*,

var. *fistulosa*. The present form frequently displays one or two rows of tubular openings on the lateral faces of the test in addition to the orifices at the peripheral ends of the chambers.

Textularia transversaria has only been observed at two points, namely:—off Raine Island, Torres Strait, 155 fathoms; and off Kandavu, Fiji Islands, 255 fathoms; in the former of which it is not uncommon.

Textularia concava, Karrer, sp. (Pl. XLII. figs. 13, 14; and Pl. XLIII. fig. 11).

Plecanium concavum, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lviii. p. 129, pl. i. fig. 3.

The typical *Textularia concava* has a compressed tapering test, with flattened or concave lateral faces, and square peripheral edges. The walls are more or less arenaceous, and the aperture is a short slit with raised border. The normal form, well portrayed Pl. XLII. fig. 14, is usually found in comparatively shallow water, and is easily recognised.

There are, however, numerous specimens, referrible to the same species, which are less angular in outline, and which, whilst preserving the flattened contour, arenaceous texture, and lipped orifice, bear otherwise considerable resemblance to such forms as *Textularia gramen*. This variety, which is generally met with at greater depths, is represented in Pl. XLIII. fig. 11.

Textularia concava has been noticed at five points in the North Atlantic, 173 to 2750 fathoms; at two in the South Atlantic, 2200 and 2475 fathoms respectively; and at seven in the South Pacific, 17 to 2600 fathoms.

The fossil specimens originally described by Dr. Karrer, were from the Miocene of Kostej in the Banat.

Textularia carinata, d'Orbigny (Pl. XLII. figs. 15, 16).

Textularia carinata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 263, No. 23.
„ „ Id. 1846, For. Foss. Vien., p. 247, pl. xiv. figs. 32–34.
„ *lacera*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesell., vol. iii. p. 84, pl. vi. figs. 52, 53.
„ *attenuata*, Id. Ibid., p. 84, pl. vi. fig. 54.
Textilaria carinata, and *Textilaria carinata*, var. *attenuata*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 489, No. 1.—Schlicht., 1870, Foram. Pietzpuhl., pl. xxxiii. figs. 1–4, 8, 9.
„ „ Hantken, 1875, Mitth. Jahrb. d. k. ung. geol. Anst., vol. iv. p. 66, pl. vii. fig. 8.

D'Orbigny's drawings of *Textularia carinata* represent an oval compressed shell, with strongly marked limbate sutures, and an irregularly toothed marginal keel. In Schlicht's figures (*loc. cit.*), assigned by Reuss to the same species, the carina is not so well defined, but the peripheral teeth are somewhat larger, and take the form of short spines;

whilst Hantken's illustrations are drawn from a specimen in which the sutures are indicated by fine lines without superficial limbation. The drawings referred to are all from fossil specimens, but in the living condition the species presents a similar diversity of character in these and other particulars. In some cases, as in the figured specimens (Pl. XLII. figs. 15, 16), the peripheral teeth are more fully developed than in any of the examples referred to, but, generally speaking, the recent test accords pretty closely with the original description.

The only Challenger locality at which *Textularia carinata* has been found is Station 209, off the Philippine Islands, 95 fathoms, where it is tolerably abundant. Its occurrence on the shores of the Adriatic is recorded by d'Orbigny and Parker and Jones.

The geological range of the species covers almost the whole Tertiary epoch. It has been obtained from the Eocene clays of the neighbourhood of London (Parker and Jones, Brady), from the Lower and Upper Oligocene, and the Septaria-clays of Germany (Reuss), from the Miocene deposits of Austria (d'Orbigny), of Malta (Brady), and of Calabria (Seguenza), and from the Pliocene beds of Italy and elsewhere (d'Orbigny, Reuss).

Textularia sagittula, Dèfrance (Pl. XLII. figs. 17, 18).

"Polymorphum *sagittula*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 120, pl. cxxxiii. fig. *T.*
Textularia sagittula, Defrance, 1824, Dict. Sci. Nat., vol. xxxii. p. 177;—vol. liii. p. 344;—Atlas, Conch., pl. xiii. fig. 5.
,, ,, Blainville, 1825, Malacologie, p. 370, pl. v. fig. 5.
,, ,, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 263, No. 20.
,, *saulcyana*, Id. 1839, Foram. Cuba, p. 137, pl. i. figs. 21, 22.
,, *cuneiformis*, Id. Ibid. p. 138, pl. i. figs. 37, 38.
,, *nussdorfensis*, Id. 1846, For. Foss. Vien., p. 243, pl. xiv. figs. 17–19.
,, *bronniana*, Id. Ibid. p. 244, pl. xiv. figs. 20–22.
,, *deperdita*, Id. Ibid. p. 244, pl. xiv. figs. 23–25.
,, *prælonga*, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 149, pl. xiii. figs. 28–30.
,, *acuta*, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 381, pl. xlix. fig. 1.
,, *cuneiformis*, Williamson, 1858, Rec. For. Gt. Br., p. 75, pl. vi. figs. 158, 159.
,, *agglutinans*, var. *sagittula*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 369, pl. xvii. fig. 77, *a.–b.*

This is perhaps the commonest of all the *Textulariæ*, whether in the recent or fossil condition. The test is elongate and much compressed, and the lateral edges are sharp, but the outline varies considerably, owing to the more rapid and more regular increase in the size of the segments in some specimens than in others. The walls are generally thick and opaque without being distinctly arenaceous.

Textularia sagittula is a cosmopolitan species, affecting most the shallow water of temperate seas; it has nevertheless been found at depths as great as 2675 fathoms in the North Atlantic, and 1425 fathoms in the South Atlantic.

As a fossil it has been obtained from the Cretaceous formations of the north of Ireland (Wright), the Eocene clays of the London Basin (Jones and Parker, Brady), the Miocene deposits of Austria, France, and elsewhere (d'Orbigny, Czjzek, &c.), the later Tertiaries of Italy (Defrance, d'Orbigny, Jones and Parker), the Crag of the east of England (Jones, Parker, and Brady), and the Post-tertiary beds of Norway, Scotland, and Ireland (Sars, Robertson, Wright).

Textularia sagittula, var. *fistulosa*, nov. (Pl. XLII. figs. 19–22).

The general characters of this variety are similar to those of the typical form, but the lateral edges of the chambers are supplemented by tubulated projections, which are directed obliquely towards the primordial end of the test, and which, when perfect, impart an irregularly dentate or serrate contour to its margin. These tubular growths are sometimes given off along the entire length of the shell, sometimes only from the earlier chambers; they are generally arranged in single file, but occasionally in a partially double or multiple row. They often open directly into the cavities of the chambers to which they are individually appended; but on the other hand, they frequently appear to form distinct supplementary chamberlets, without any orifice in the enclosed portion of the primary wall. In the latter condition it is probable that communication originally existed, and that it has been gradually closed by the subsequent thickening of the shell.

The fistulose condition of *Textularia sagittula* appears to be the result of redundant growth; and it is principally met with in specimens from tropical and sub-tropical latitudes.

Textularia siphonifera, H. B. Brady (Pl. XLII. figs. 25–29).

Textularia siphonifera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 53.

Test free; elongate, subcylindrical, nearly round in transverse section, tapering and pointed at the primordial end; each of the two opposing series of segments furnished with numerous fistulæ (or supplementary chambers?), most of them with rounded external orifices, arranged in from two to four, more or less regular, longitudinal rows. Length, $\frac{1}{16}$th inch (1·5 mm.) or less.

It is often very difficult to determine the relation of the lateral fistular growths of the *Textulariæ* to the segments with which they appear to be immediately connected. In the present species I have never been able to trace, either by sections or otherwise, any well-marked orifice in the included portion of the primary wall, and in the absence of such connection the "fistulæ" can only be regarded as supplementary chamberlets.

The drawing (fig. 29) represents accurately the transverse section of a shell having

three rows of outgrowths on each side. As already stated with reference to the redundant variety of *Textularia sagittula*, it appears probable that there is originally, in every case, a communication between the chamberlet and the adjacent chamber by means of a stoloniferous pore, but that this is subsequently filled up as the walls become thickened by the deposit of shell-substance. The fistulæ for the most part have large, rounded, external apertures, but in some of them the visible orifice is only a minute perforation, and in specimens from certain localities they are frequently entirely closed in.

Textularia siphonifera has been observed in sands from the coral-reefs of Honolulu, Sandwich Islands, 40 fathoms; from two points off the Admiralty Islands, 15 to 25 fathoms; from off Tongatabu, Friendly Islands, 18 fathoms; and in material dredged by the late Mr. M'Andrew in the Gulf of Suez, 30 fathoms.

Textularia rugosa, Reuss, sp. (Pl. XLII. figs. 23, 24).

Plecanium rugosum, Reuss, 1869, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lix. p. 453, pl. i. fig. 3, *a.b.*

Reuss's figure of *Plecanium rugosum* appears to have been drawn from a comparatively poor fossil specimen of the species, represented in its recent condition in figs. 23 and 24.

The salient character of the test is a certain imbricated or plicate appearance, due to the peculiar curvature of the segments, and to a series of transverse arched depressions immediately above the sutural lines, near the peripheral margin, on each side. Living specimens sometimes attain a length of $\frac{1}{12}$th inch (2 mm.) or more.

Textularia rugosa is a coral-reef species. It occurs off the Admiralty Islands, 10 to 25 fathoms; off Booby Island, 7 fathoms; off Tongatabu, Friendly Islands, 18 fathoms; off Ascension Island, 7 fathoms; and in the Gulf of Suez, 30 fathoms; as well as in deep water off Amboyna.

The specimens described by Reuss were from the Oligocene formation of Gaas, near Dax, in the south of France.

Textularia agglutinans, d'Orbigny (Pl. XLIII. figs. 1–3; vars. figs. 4, 12).

Textularia agglutinans, d'Orbigny, 1839, Foram. Cuba, p. 136, pl. i. figs. 17, 18, 32–34.
Textilaria agglutinans, Seguenza, 1862, Atti dell' Accad. Gioenia, vol. xviii. (ser. 2) p. 112, pl. ii. fig. 4.
Plecanium sturi, Karrer, 1864, Sitzungsb. d. k. Ak. Wiss. Wien, vol. l. p. 704, pl. i. fig. 1.
Textularia agglutinans, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 369, pl. xv. fig. 21.
Plecanium agglutinans, Reuss, 1869, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lix. p. 452, pl. i. figs. 1, 2.
Textilaria agglutinans, Mœbius, 1880, Foram. von Mauritius, p. 93, pl. ix. figs. 1–8.

This species may be taken as the type of the arenaceous varieties of *Textularia*, which collectively form the genus *Plecanium* of Reuss and others. D'Orbigny's figures

represent an elongated tapering test, nearly circular in transverse section, and rough externally. The species is minutely described by Moebius (*loc. cit.*); and the calcareous lining of the test as well as the tubulated structure of the outer walls are excellently illustrated in his drawings. The chamber-cavities are either simple, or partially subdivided by irregular secondary septa.

In its normal condition the pseudopodial orifice is a curved or straight fissure at the inner margin of the terminal segment, close to the line of union with the penultimate. In rare instances the aperture is porous, as shown in fig. 3.

Fig. 12 represents a specimen which has been broken and repaired, the surface of which is traversed by partial longitudinal costæ. Superficial ornament of any sort, distinct from mere sutural limbation, is a rare feature amongst the *Textulariæ*, and in the present case it is of particular interest in connection with certain Carboniferous fossils (*Textulariæ* and *Bigenerinæ*), figured by von Möller under the names *Cribrostomum elegans*, *Cribrostomum eximium*, *Cribrostomum commune*, &c. (Mém. de l'Acad. Sci. St.-Pétersb., sér. 7, vol. xxvii. No. 5, pls. iii. iv.), which exhibit a similar form of decoration.

In some localities, especially about the coral-reefs of the tropics, much elongated, subcylindrical, arenaceous *Textulariæ*, such as that portrayed in Pl. XLIII. fig. 4, *a.b.*, are very common. The test consists, as a rule, of a large number of segments, and tapers very gradually towards the aboral end, but in other respects the characters are those of the typical form. This variety may be distinguished as *Textularia agglutinans*, var. *porrecta*.

Textularia agglutinans is distributed over the whole world, without much reference to the depth of the sea-bottom, its bathymetrical range extending from 5 fathoms to 3125 fathoms.

It is difficult to fix the earliest appearance of the species as a fossil, owing partly to the similarity in general contour of a number of forms which are known under different names, and partly to the effect of infiltration and external agencies in obscuring the minute structure of arenaceous tests. Parker and Jones state, in general terms, that it occurs amongst the microzoa of the secondary formations, but the earliest formation from which there is any distinct record of its having been obtained is the Eocene clay of the London Basin. It has been found in the Oligocene of Gaas, near Dax (Reuss), in the Miocene "Leythakalk," of West Slavonia (Karrer), in the Pliocene of Italy (Parker and Jones), in the Crag of the east of England (Jones, Parker, and Brady), and in the Pleistocene of Sicily (Seguenza).

Textularia luculenta, n. sp. (Pl. XLIII. figs. 5–8).

Test compressed, tapering; oral end rounded or truncate, aboral extremity obtusely pointed; peripheral edges rounded, irregular or slightly lobulated. Segments numerous,

ten to fifteen in each rank, compactly fitted; sutures even, marked by fine lines with little or no external depression. Aperture, in the earlier stages, a curved slit, in the normal Textularian position; in the adult shell, a round perforation situated in a depression on the distal face of the terminal chamber. Texture finely arenaceous, surface nearly smooth. Length, $\frac{1}{10}$th inch (2·5 mm.).

This is a tolerably well-marked species, both in respect of general contour and the mode of combination of the chambers; but it derives its chief interest from the tendency of the aperture in the later segments to assume a terminal instead of a lateral position. The importance of this occasional feature of the *Textulariæ* has been much exaggerated, and it has even been employed as the distinctive character of a separate genus, *Proroporus*. The structural change involved is in reality very slight, as may be seen from the sectional drawing (fig. 8), in which the transition from one position to the other is clearly shown.

Textularia luculenta has been obtained at five localities, three of which are in the North Atlantic, namely:—off Sombrero Island, 450 fathoms; off Culebra Island, 390 fathoms; and off Bermuda, 435 fathoms; and at two in the South Atlantic, near the coast of South America, a little south of Pernambuco, 675 fathoms and 350 fathoms respectively.

Textularia gramen, d'Orbigny (Pl. XLIII. figs. 9, 10).

Textularia gramen, d'Orbigny, 1846, For. Foss. Vien., p. 248, pl. xv. figs. 4. 6.

The *Textularia gramen* of d'Orbigny forms a good central type of the broad, stout varieties of the genus, which have subangular or rounded lateral edges and coarsely constructed tests. From this species, *Textularia hauerii* (For. Foss. Vien., p. 250, pl. xv. figs. 13–15), and *Textularia abbreviata* (Id., p. 294, pl. xv. figs. 7–12) differ only in slight modifications of outline, the former having less angular edges, the latter being of somewhat shorter and thicker contour.

Textularia gramen is found at almost all latitudes, but is commoner on shallow bottoms than at great depths.

It is difficult to identify the various common forms of fossil *Textulariæ* described under different names by successive authors, but it is probable that the present species has a wide range amongst Tertiary microzoa. D'Orbigny's specimens were from the Miocene of Baden, near Vienna.

Textularia conica, d'Orbigny (Pl. XLIII. figs. 13, 14; Pl. CXIII. fig. 1, *a.b.*).

Textularia conica, d'Orbigny, 1839, Foram. Cuba, p. 135, pl. i. figs. 19, 20.

D'Orbigny's term, *Textularia conica*, may be conveniently employed for the very short, more or less compressed varieties of the genus, common in shallow-water sands, especially

in the tropics. The test is sometimes compressed throughout, and the distal end of long oval shape, as shown in Pl. CXIII. fig. 1; but more commonly the later segments widen rapidly and the end is broadly elliptical. The walls are thin and non-labyrinthic, often somewhat arenaceous, and rough externally. The species differs from *Textularia trochus* in its simple, non-labyrinthic test, compressed contour, and roughish exterior.

Textularia conica is a very generally diffused species, commonest perhaps on the coral-reefs of the Eastern Archipelago and the West Indies.

Textularia trochus, d'Orbigny (Pl. XLIII. figs. 15–19; Pl. XLIV. figs. 1–3).

Textularia trochus, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. p. 45, pl. iv. figs. 25, 26.
„ *cuneiformis*, var. *conica*, Williamson, 1858, Rec. For. Gt. Br., p. 75, pl. vi. figs. 160, 161.
„ *trochus*, Jones, Parker, and Brady, 1865, Foram. Crag., pl. iii. figs. 17, 18.
„ „ Vanden Broeck, 1876, Ann. Soc. Belg. Micr., vol. ii. p. 132, pl. iii. figs. 11, 12.

Under the term *Textularia trochus* may be included all the shorter conical varieties of the genus that are circular in transverse section from the commencement. Generally speaking, the height of the test is but little greater than the diameter at the oral end, and is sometimes much less. Under favourable conditions, the walls exhibit a tendency to become thick and labyrinthic, and the sutures limbate externally. The length (or height) seldom exceeds $\frac{1}{25}$th inch (1 mm.). These characters are sufficient to distinguish the species from the closely-allied *Textularia turris*, *Textularia conica*, and *Textularia barrettii*.

Textularia trochus is a cosmopolitan form, reaching its highest development in tropical and subtropical latitudes, and its greatest abundance amongst coral-sands.

It is well known as a Cretaceous fossil; and has been observed in the later Tertiary deposits of Sicily and in the Crag of the east of England.

Textularia turris, d'Orbigny (Pl. XLIV. figs. 4, 5).

Textularia turris, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. p. 46, pl. iv. figs. 27, 28.
„ „ Parker and Jones, 1863, Ann. and Mag. Nat. Hist., ser. 3, vol. xi. p. 97.

Textularia turris is round in transverse section, elongate, and tapering. It differs from *Textularia trochus* chiefly in its greater proportionate length and its rougher exterior, as well as in its frequent irregularity of contour. Recent specimens are sometimes $\frac{1}{8}$th or even $\frac{1}{6}$th inch (3 to 4 mm.) in length.

Well-marked examples of *Textularia turris* are rare in the living condition. It has

only been observed at two Challenger Stations, namely:—off Culebra Island, 390 fathoms; and off the coast of South America, south-east of Pernambuco, 350 fathoms.

As a fossil the species is much better known. It occurs in the Cretaceous beds of France, Bohemia, England, and Ireland (d'Orbigny, Reuss, Wright), in the Eocene clays of the London Basin, and in the later Tertiary deposits of Italy and Sicily (Parker and Jones).

Textularia barrettii, Jones and Parker (Pl. XLIV. figs. 6–8).

Textularia barrettii, Jones and Parker, 1863, Report Brit. Assoc., Newcastle Meeting, p. 80 and p. 105.
„ „ Id. 1876, Ann. Soc. Malac. Belg., vol. xi. p. 99, woodcut.

This is a fine and striking species. The test is usually a somewhat elongated cone, which is oval or compressed in transverse section; but the plane of compression is in the opposite direction to that usual in Textularian shells, namely, on a line parallel to the plane of union between the two series of segments (fig. 6, *b*.). The walls are arenaceous but the exterior is smooth and neatly finished, and the sutures are marked by fine lines without superficial depression. The chamber-cavities are labyrinthic, and the margin of the aperture is often denticulated. The test attains large dimensions, occasionally as much as $\frac{1}{6}$th inch (4·2 mm.) in length, with a breadth nearly as great at the oral end.

Textularia barrettii is closely allied to *Textularia trochus;* its peculiar oval contour and relatively large size being the chief points of distinction.

The species has been observed at the following localities:—off Bermuda, 435 fathoms; off Culebra Island, 390 fathoms; off Jamaica, 100 to 250 fathoms; and south-east of Pernambuco, 350 fathoms. I have specimens also from Port Jackson, Australia, but unaccompanied by any particulars as to depth.

In addition to the living specimens dredged by the late Mr. Barrett on the coast of Jamaica, Jones and Parker report the occurrence of the species in the fossil condition in the Miocene deposits of that island.

Textularia aspera, H. B. Brady (Pl. XLIV. figs. 9–13).

Textularia aspera, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 715.

Test free or adherent; oblong, subovate, slightly compressed, somewhat tapering; oral end rounded or obliquely truncate, aboral extremity obtuse, lateral edges rounded. Segments few, three or four in each series, inflated; sutures excavated. Texture coarsely arenaceous; colour brown, grey, or nearly white. Length, $\frac{1}{20}$th inch (1·26 mm.) or more.

This species, which was briefly described in the Report on the Foraminifera of the "Knight Errant" Expedition, is very variable in external appearance. The test is always arenaceous and often loosely built; it is oblong and rounded in form, and consists of only a small number of segments. In the North Atlantic it is found in company with other arenaceous Foraminifera at moderate depths, and is often parasitic upon the tests of larger forms such as *Rhabdammina* (fig. 9). In deep water it exhibits a tendency to become triserial. The North Atlantic specimens are generally of rich brown colour, whilst those from elsewhere, especially such as have their home amongst coral-sand, are more frequently of white or light-grey hue; sometimes both brown and white specimens occur in the same dredging.

Textularia aspera has been obtained at five Stations in the North Atlantic, ranging in depth from 390 to 530 fathoms; at three in the South Atlantic, 350 to 1435 fathoms; and at two in the South Pacific, 175 and 210 fathoms respectively.

Bigenerina, d'Orbigny.

Nautilus, pars, Batsch [1791].
Orthoceratia, pars, Soldani [1791].
Bigenerina, d'Orbigny [1826], Römer, Reuss, Costa, Parker and Jones, Karrer, Brady, Schwager, M. Sars, Vanden Broeck, Winther, Terrigi, &c.
Gemmulina, d'Orbigny [1826].
Vulvulina, pars, d'Orbigny [1826], Reuss.
Clavulina, pars, d'Orbigny [1839], Karrer.
Grammostomum, Reuss [1845], Parker and Jones, Brady.
Polymorphina, pars, Ehrenberg [1854].
Schizophora, Reuss [1861], Hantken, Karrer, Seguenza, Schlumberger.
Venilina, Gümbel [1868].
Climacammina, Brady [1876], Schwager.
? *Stylolina*, Karrer [1877].
Cribrostomum, pars, Möller [1879].

The genus *Bigenerina* is represented morphologically by a Textularian shell with the addition of one or several uniserial segments, and d'Orbigny's original description of the type is based simply on the dimorphous condition of the test. The relative development of the biserial and uniserial portions varies a good deal; in some cases the Textularian segments are comparatively inconspicuous, and do not occupy collectively more than one-fourth of the entire length, whilst in others they form the principal part of the test. The Nodosarian segments vary in number from one to eight or nine.

Of all the Textularian genera, *Bigenerina* has the nearest affinity to *Textularia* proper; its range of variation in minor characters is in many respects similar to that of the typical group and almost equally extensive. Thus, amongst the *Textulariæ* there are conical, subcylindrical, compressed, and carinate forms; so in *Bigenerina* may be found cylindrical, compressed, carinate, and other isomorphous varieties: in *Textularia* the aper-

ture, normally a transverse fissure, sometimes takes the form of a bordered lateral orifice, a rounded central perforation, or a number of pores on the distal face of the last segment; so in *Bigenerina*, though represented typically by a central rounded opening, it frequently assumes the character of an oval, elongate, or fissurine orifice, or of a number of terminal pores.

Many of these characters will be referred to again in the description of the species by which they are exemplified. The importance of some of them has been exaggerated, and in certain cases they have been treated as distinctions of generic value; but amongst the typical *Textulariæ* in which their relative significance is more easily observed, such peculiarities are found in many instances insufficient for even specific diagnosis, and there can therefore be no good reason for making them a basis for the generic subdivision of a comparatively small subordinate group like the *Bigenerinæ*.

The geographical distribution of the genus *Bigenerina* presents somewhat marked features. It is very common in the North Atlantic, tolerably common in the Mediterranean and Adriatic, and much less frequent in the South Atlantic, whilst it is very rare in the North Pacific, and almost entirely wanting in the Southern Ocean and the South Pacific.

In the fossil condition it is met with in various Tertiary formations, making its first appearance in the Eocene period.

Bigenerina nodosaria, d'Orbigny (Pl. XLIV. figs. 14–18).

Bigenerina nodosaria, d'Orbigny, 1826, Ann. Sci Nat., vol. vii. p. 261, No. 1, pl. xi. figs. 9–12. —Modèle No. 57.
„ *pusilla*, Roemer, 1838, Neues Jahrb. für Min. &c., p. 384, pl. iii. fig. 20.
„ *agglutinans*, d'Orbigny, 1846, For. Foss. Vien., p. 238, pl. xiv. figs. 8–10.
„ *torulosa*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 285, pl. xv. fig. 12.
„ *anulata*, Id. Ibid. p. 284, pl. xv. fig. 13.
„ *bifida*, Id. Ibid. p. 287, pl. xxiii. fig. 1.
Clavulina elegans, Karrer, 1864, Novara-Exped., geol. Theil, vol. i. p. 80, pl. xvi. fig. 11.
Textularia agglutinans, var. (*Bigenerina*) *nodosaria*, Parker and Jones, 1865, Phil. Trans., vol. clv p. 371, pl. xv. fig. 25; pl. xvii. fig. 80.
Bigenerina nodosaria, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 192, pl. ii. fig. 28.

In *Bigenerina nodosaria* the Textularian portion of the test is much compressed, and tapers to a point at the aboral extremity. It is generally also a good deal broader than the adjoining segments of the linear series, and the alternate arrangement of the chambers is more or less distinctly marked externally. The uniserial portion in adult specimens consists of about four segments, each somewhat larger than its predecessor, usually gibbous or rounded in contour, and the sutures correspondingly sunken.

Bigenerina nodosaria is a common North Atlantic species. It has been met with as far north as the Hunde Islands, Davis Strait, 25 to 70 fathoms (Parker and Jones); and occurs in the Faröe Channel, 155 fathoms; off Shetland and amongst the Hebrides, 80 to

140 fathoms; and at seven "Porcupine" Stations to the west of Ireland, at depths varying from 85 to 1630 fathoms. It has been observed both in the Mediterranean and the Adriatic. In the North Pacific it has been found in shallow water at three localities, namely:—the Inland Sea, Japan, 15 fathoms, the Chinese Sea, and in Hong Kong Harbour, 7 to 10 fathoms. In the southern hemisphere the species is exceedingly rare, nevertheless, it has been taken in Humboldt Bay, Papua, just south of the equator, 37 fathoms, and at one point in the South Atlantic, 260 fathoms.

As a fossil its range does not extend much beyond the middle of the Tertiary epoch. It is found in the Miocene of the Vienna Basin, and of Malta (d'Orbigny, Parker and Jones); and in the later Tertiaries of North Germany (Roemer), of Italy (Costa, Terrigi, and others), and of Spain (Parker and Jones).

Bigenerina digitata, d'Orbigny (Pl. XLIV. figs. 19–24).

Bigenerina (*Gemmulina*) *digitata*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 262, No. 4.—Modèle, No. 58.

Bigenerina digitata, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 468, pl. xlviii. fig. 8.

Textularia agglutinans, var. (*Bigenerina*) *digitata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 371, pl. xvii. fig. 81.

Bigenerina digitata, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 28, pl. ii. fig. 61.

The test of *Bigenerina digitata* is cylindrical, and tapers very gradually towards the aboral end, which is subconical or rounded, not compressed. The transition from the Textularian to the Nodosarian mode of growth is not marked by any difference in external contour as in the allied *Bigenerina nodosaria*. The walls are constructed of fine siliceous grains, neatly joined by means of a dark-coloured cement; and the exterior is nearly smooth. The test is of rich brown hue, often lighter towards the distal end. The aperture is usually central, but sometimes it is excentric or even marginal; its occurrence in the latter position was put forward by d'Orbigny as the distinctive character of his subgenus *Gemmulina*.

Bigenerina digitata is only known as a European Foraminifer. The record of its distribution in the living condition is limited to the eastern shores of the North Atlantic, and the coasts of the Mediterranean and the Adriatic. It has been dredged off Shetland, off the Hebrides, and at four "Porcupine" Stations off the west coast of Ireland, at depths ranging from 40 to 1230 fathoms, and in shallow water off the coast of Denmark. It occurs in the lagoons and littoral sands of the Adriatic, and at a depth of 40 fathoms in the Mediterranean.

In the fossil state it has been observed in the later Tertiaries of Italy (Parker and Jones, Seguenza), and of the neighbourhood of Malaga (Parker and Jones).

Bigenerina robusta, H. B. Brady (Pl. XLV. figs. 9–16).

Bigenerina robusta, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 53.

Test elongate, subcylindrical: early portion compressed, and tapering to a blunt point, composed of a number of segments arranged, as in *Textularia*, in two more or less regular alternating series: later portion cylindrical, convex or truncate at the distal end; consisting of numerous very short segments, the marginal outline of which is often ventricose and irregular. Aperture in the early stage Textularian in form and position; in adult specimens terminal and porous. Length, $\frac{1}{6}$th inch (4·2 mm.), sometimes more.

In certain localities where arenaceous *Textulariæ* are abundant and grow to a large size, the specimens are apt to assume considerable diversity of form. Some of them, perhaps the largest number, are tolerably regular in contour and mode of growth; others, though irregular, complete their tests in the normal biserial manner; whilst the rest become dimorphous, and put on a number of uniserial segments. In rare instances, the tests, which retain their Textularian character to maturity, exhibit a porous aperture (Pl. XLIII. fig. 3), but in the dimorphous or Bigenerine condition the multiple orifice is an almost invariable feature, the only exceptions being those in which the pores have coalesced so as to form a single irregular opening. In view of these facts, it is probable that, notwithstanding the strikingly distinct appearance of *Bigenerina robusta*, it may represent nothing more than a local dimorphous variety of *Textularia agglutinans*.

Monstrous specimens, in which the organism has divided at an early stage, or otherwise given rise to two or three cohering individuals are not uncommon, and they serve to show how little value is to be attached to the form of the aperture as a zoological character. Examples of this sort are represented in Pl. XLV. figs. 15 and 16, the former of which is a double shell, one individual having a Textularian the other a porous aperture; whilst the latter consists of three tests united at the base, one of them still in the Textularian stage, another with an irregular central orifice, and the third in the more common condition, with a number of pores near the middle of the final segment.

One of the most interesting points in connection with this species is its close resemblance to certain Carboniferous fossils, described several years ago under the name *Climacammina antiqua*.[1] The affinity of these fossils to the genus *Bigenerina* was to some extent recognised, and the term *Climacammina* was introduced provisionally,

[1] Monograph of Carboniferous and Permian Foraminifera, p. 68, pl. ii. figs. 1–9, and on a later page a more regular specimen of the same species appears under the name *Bigenerina patula*, p. 136, pl. viii. figs. 10, 11, and pl. x. figs. 30, 31.

Since the publication of the Monograph, the same forms have been described by von Möller, under the names *Cribrostomum pyriforme*, *Cribrostomum patulum*, &c., *Mém. de l'Acad. Imp. Sci. St.-Pétersbourg*, ser. 7, vol. xxvii. No. 5, pp. 57, 65, &c.

Should further research show, as I believe it will, that the palæozoic and recent specimens belong zoologically to identical species, the name *Bigenerina patula* would take precedence of *Bigenerina robusta*.

and not without hesitation; but there can no longer be any doubt that it was a needless addition to the nomenclature of the group. Indeed, making allowance for the geological age of the specimens referred to and the changes brought about by the process of mineralisation, by pressure, or by other external influences to which they have been subjected, it is not easy to find any constant or reliable character by which they can be separated from the recent species. The interior of some of the fossil tests is more or less labyrinthic; but this is not always the case, and the Russian specimens of the same form, figured by von Möller, resemble the living ones in this respect.

Bigenerina robusta is common at Station 24, off Culebra Island, West Indies, 390 fathoms, and at Station 122, South Atlantic, south-east of Pernambuco, 350 fathoms. It occurs also in one of Dr Gwyn Jeffreys' dredgings in shallower water off Shetland.

Bigenerina capreolus, d'Orbigny, sp. (Pl. XLV. figs. 1–4).

Vulvulina capreolus, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 264, No. 1, pl. xi. figs. 5, 6—Modèle, No. 59.
Schizophora neugeboreni (?) Reuss, 1861, Sitzungsb. d. k. böhm. Gesell. d. Wiss., vol. ii. p. 13.
Grammostomum capreolus, Parker and Jones, 1863, Ann. and Mag. Nat. Hist., ser. 3, vol. xi. p. 93.
Textilaria flabelliformis (young stage), Gümbel, 1868, Abh. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 647, pl. ii. fig. 83, *a.–b.*
Venilina hæringensis, Id. Ibid. p. 649, pl. ii. fig. 84, *bis.*, *a.b.*
Schizophora hæringensis, Hantken, 1872, Mittheil. Jahrb. d. k. ungar. geol. Anstalt., vol. i. p. 136, pl. ii. fig. 17, *a.b.*

The test of *Bigenerina capreolus* is broad and compressed, and the lateral edges sharp and frequently more or less pectinate. The uniserial chambers are few in number, adult specimens very often consisting of a Textularian shell, with the addition of only one or two centrally-placed segments. The aperture in the early stage is Textularian; in the later period terminal, and of fissurine or oval shape.

This species was adopted by d'Orbigny as the type of his genus *Vulvulina;* and although in the generic description it is stated that the arrangement of the segments is alternate throughout, the author appears to have been in some degree aware of its dimorphous tendency, inasmuch as one at least of the Soldanian figures referred to represents a shell with two uniserial segments. The term *Grammostomum*[1] was subsequently employed by Reuss and others for the same group, more perhaps in order to avoid confusion between *Vulvulina* and *Valvulina* than for any better reason.

In 1861 Reuss instituted a new genus *Schizophora*, which was intended to include all species commencing growth on the Textularian plan, and resembling *Lingulina* in their later development; and more recently Gümbel has proposed the term *Venilina* for the

[1] The term *Grammostomum* was borrowed from Ehrenberg, but Parker and Jones have since shown, in their laborious analysis of the nomenclature of the various works of that author, that it was used by him indifferently for *Textulariæ*, *Vulvulinæ*, *Bolivinæ*, *Virgulinæ*, and *Polymorphinæ*.

same set of forms. Schwager, however, takes what appears to be a much more reasonable view of the features in question, and in his admirable memoir on fossil Foraminifera from the Nicobar Islands, has assigned one of these compressed and carinate forms to the genus *Bigenerina*, thereby asserting their affinity with the cylindrical varieties having the same typical structure. It is true that the aperture of *Bigenerina capreolus* and *Bigenerina pennatula*, adapting itself to the shape of the terminal segment, is generally fissurine; but this character, which only applies to the later portion of the test, is by no means invariable, and examples are not wanting in which the orifice is of oval form, and differs but little from that of occasional specimens of the cylindrical species.

In the recent condition, *Bigenerina capreolus* is best known as a North Atlantic type. It is found in some of the "Porcupine" dredgings, but I have not been able to trace it further north than about lat. 50° N. It is common off the Azores, 450 fathoms; off the Canaries, 600 fathoms; and off the Danish West Indies, 390 to 450 fathoms. In the South Atlantic it has been taken at two Stations, off the coast of South America, near Pernambuco, depth 350 and 675 fathoms respectively. The specimens originally described by d'Orbigny were obtained from the Adriatic.

Owing to the confusion of names, there is some uncertainty in the record of the occurrence of the species in the fossil condition, and it is difficult to state its geological distribution with any degree of accuracy. It is known, however, to occur as far back as the Eocene formation of the Bavarian Alps (Gümbel), and the *Clavulina-szabói* beds of Hungary (Hantken); and there is little doubt of its presence in company with *Bigenerina pennatula* in the later Tertiaries of Italy.

Bigenerina pennatula, Batsch, sp. (Pl. XLV. figs. 5–8).

"Orthoceratia *Pupa*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 99, pl. cviii. fig. *D.E.F.*
Nautilus (*Orthoceras*) *pennatula*, Batsch, 1791, Conchyl. des Seesandes, No. 13, pl. iv. fig. 13, *a.–d.*
Vulvulina elegans, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 264, No. 3.
Lingulina soldanii, Id. Ibid. p. 257, No. 3.
Textularia corrugata, Costa, 1857, Mem. Acad. Sci. Napoli, vol ii. p. 125. pl. i. fig. 15.
Bigenerina nicobarensis, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 196, pl. iv. fig. 7, *a.–c.*
Venilina nummulina, Gümbel, 1868, Abh. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 648, pl. ii. fig. 84, *a.b.*
Grammostomum elegans, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 170, p. xi. figs. 121, 123.

Bigenerina pennatula is very closely related to the species last described, but differs from it in the obtuse rounded outline of the aboral end of the test, the relatively smaller number of Textularian segments, and the increased development of the linear series.

The Textularian segments are a good deal arched, the curvature of the earlier ones being sometimes sufficient to give a distinctly spiral arrangement to the commencement of the shell. This feature, which is shown in the specimen represented in Pl. XLV. fig. 7, is well illustrated by Batsch in his sectional drawing (*loc. cit.*, fig. 13 *d*).

The geographical distribution of *Bigenerina pennatula* is practically the same as that of *Bigenerina capreolus*, with which it is generally found associated; and the geological range of the two species appears to be nearly coincident.

Pavonina, d'Orbigny.

Pavonina, d'Orbigny [1826], Bronn, Brady, Moebius.

The genus *Pavonina* was originally described in the Tableau Méthodique, in which it was placed at the end of the Family *Stichostègues*, the multiple aperture, depressed test, and concentric chambers being given as the distinctive characters. Comparatively recently it has been shown that the test is in reality dimorphous, and that only the later segments are disposed concentrically, the earlier ones being alternate and Textularian. Our knowledge of the type is confined to a single species.

Pavonina flabelliformis, d'Orbigny (Pl. XLV. figs. 17–21).

Pavonina flabelliformis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 260, No. 1, pl. x. figs. 10, 11.—Modèle, No. 56.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 68, pl. viii. figs. 29, 30.
„ „ Moebius, 1880, Foram. von Mauritius, p. 91, pl. viii. figs. 11, 12.

The test of *Pavonina flabelliformis* is complanate and spreading, and except for some thickening of the earlier portion, the two faces are nearly flat; the general outline is fan-shaped or reniform. The early segments are small and arranged alternately as in *Textularia*. The later segments are narrow and much arched, and are disposed in single series; they extend from one lateral margin to the other, and increasing rapidly in length give the test its fan-like contour. The shell-wall is thin and transparent, the perforations numerous and large, and often arranged in two or three irregular rows on the lateral faces of each segment; and the sutures are limbate externally. The general aperture consists either of a single row of rounded orifices on the septal plane of the final segment (fig. 20), or of a larger number of smaller pores disposed in regular lines (as in Moebius' drawings, *op. cit.*), or irregularly (fig. 21). When the apertural pore-canals are minute, they are somewhat prolonged outwards in the form of short delicate projecting tubes (Moebius, pl. viii. figs. 13 *r*, 14 *r*); but when the orifices are of larger size and in single row, the edges are only thickened sufficiently to form

a slightly raised border. The diameter of the larger specimens is about $\frac{1}{28}$th inch (0·9 mm.).

Apart from the peculiarity of its structure, *Pavonina flabelliformis* derives some interest from the fact that, after its discovery by d'Orbigny in 1826 or earlier, the species was lost sight of for more than fifty years, and during that time, in the absence of specimens, various conjectures were made as to the affinities of the type, all of which have proved to be far wide of the mark. The specimens originally described were found by d'Orbigny in shore-sand from Madagascar, and it has been with great pleasure that I have recently met with the species in similar material collected by my friend Mr. L. Kitching near Tamatavé, on the east coast of that island.

I have notes of the occurrence of *Pavonina flabelliformis* from nine or ten localities, namely:—off Culebra Island, West Indies, 390 fathoms; Madagascar, shore-sand; Seychelle Islands, shallow water; Port Louis, Mauritius, harbour mud; off Calpentyn, Ceylon, 2 fathoms; off Raine Island, Torres Strait, 155 fathoms; Nares Harbour, Admiralty Islands, 17 fathoms; and Honolulu Reefs, 40 fathoms. Moebius' specimens were from the Mauritius, and in Mr. F. W. Millett's collection there are examples from the coast of the Korea.

Spiroplecta, Ehrenberg.

Heterohelix, Ehrenberg [1843].
Spiroplecta, Ehrenberg [1844], Parker and Jones, Brady, Balkwill and Wright.
Textularia (pars), Parker and Jones [1865], Brady, Norman.

The term *Heterohelix* was originally assigned by Ehrenberg to this group of *Textularinæ*, but was almost immediately changed by him, for no very obvious reason, to *Spiroplecta*. The latter name is now in very general use, and there seems no advantage in reverting to the earlier one on the mere ground of priority, as the same author is concerned with both.

The test of *Spiroplecta* is normally dimorphous; the chambers are planospiral at the commencement and are subsequently arranged, as in *Textularia*, in two alternating series. In rare instances it exhibits a tendency to become trimorphous, by the further addition of a line of uniserial chambers with a central terminal aperture.

The test presents the same degree of variation in point of texture as that of the typical *Textulariæ*; it is thin and transparent in *Spiroplecta rosula*, thicker and opaque in *Spiroplecta annectens*, and coarsely arenaceous in *Spiroplecta biformis*.

The two species of *Spiroplecta* described by Ehrenberg in the Mikrogeologie, were based on specimens of Cretaceous age, and there does not appear to be any record of the occurrence of the genus between the Mesozoic and the Post-tertiary formations. In the living condition the type is widely distributed but by no means common.

Spiroplecta americana, Ehrenberg (Pl. XLV. fig. 24, *a.b.*).

Spiroplecta americana, Ehrenberg, 1854, Mikrogeologie, pl. xxxii. I. figs. 13, 14; II. fig. 25.

This species is distinguished from its congeners by the general contour of the test. The shell is usually much compressed, and widens rapidly towards the distal end; the lateral edges are thin and slightly lobulated, the chambers somewhat inflated, and the septal lines correspondingly depressed on the exterior; the walls are thin and smooth, and in small specimens hyaline.

Spiroplecta americana has only been found living in one locality, off Raine Island, Torres Strait, depth 155 fathoms.

The specimens figured by Ehrenberg were from the Cretaceous beds of Missouri and Mississippi, North America.

Spiroplecta annectens, Parker and Jones, sp. (Pl. XLV. figs. 22, 23, *a.b.*).

Textularia annectens, Parker and Jones, 1863, Ann. and Mag. Nat. Hist., ser. 3, vol. xi. p. 92, woodcut, fig. 1.

Under the name *Textularia annectens*, Parker and Jones have described and figured a very long and slender variety of *Spiroplecta*, found by them in the Gault, which presents the trimorphous characters already referred to, owing to the addition of a variable number of uniserial segments to the normal dimorphous shell.

The recent specimens figured in Pl. XLV. figs 22, 23, exhibit well the attenuated form of the test, and the characteristic arrangement of the chambers—planospiral at first, then biserial and alternate; but they terminate in a single centrally-placed segment. Since these drawings were made, however, other specimens have been found, in material from the same locality, which have an addition of two or three uniserial chambers. The recent examples appear to be altogether more regular in contour than those from Cretaceous sources, though they agree in essential particulars.

Spiroplecta annectens is not uncommon at Station 185, off Raine Island, Torres Strait, 155 fathoms, and small specimens occur in a neighbouring locality, Station 192, off Ki Islands, 140 fathoms, but the species has not been found elsewhere.

Parker and Jones state that it occurs, in company with other partially spiral Textularians, in the Gault of the south-east of England.

Spiroplecta biformis, Parker and Jones, sp. (Pl. XLV. figs 25–27).

Textularia agglutinans, var. *biformis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 370, pl. xv. figs. 23, 24.

„ *biformis*, Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 436, pl. xx. fig. 8.

This form is described by Parker and Jones (*loc. cit.*), as "a small *Textularia* with a sandy shell, often of a rusty colour, with scarce any shell-substance proper,—with a

spiral commencement, the later chambers subquadrate and arranged alternately." They further state that it "may be regarded as an arrested form of *Textularia annectens*.

Spiroplecta biformis is distinguished from its allies by its small size and invariably arenaceous test, its nearly uniform width and rounded lateral edges. In the recent condition, at any rate, it is far removed from *Spiroplecta annectens*, and there seems no reason to regard it as an arrested form in any ordinary sense of the term.

Under the name *Spiroplecta rosula*,[1] Ehrenberg has figured a Cretaceous species closely resembling that under notice in general contour, but with a hyaline and perforate shell; and this also is occasionally met with in the living condition.[2]

Amongst the Challenger gatherings *Spiroplecta biformis* is exceedingly scarce, having only been observed at two localities, namely:—Station 323, South Atlantic, east of Buenos Ayres, 1900 fathoms; and Station 285, South Pacific, mid-ocean, 2375 fathoms. It has been found by Wright and Balkwill in shallow water on the coast of Ireland. But it is as an arctic species that it is best known, indeed until recently its distribution was supposed to be confined to high latitudes. The following are some of the northern localities from which specimens have been obtained:—Franz-Josef Land, lat. 79° to 80° N., 113 to 145 fathoms; west coast of Novaya Zemyla, 55 to 70 fathoms; Baffin's Bay and Smith Sound, 27 to 80 fathoms; and the Hunde Islands, Davis Strait, 60 to 70 fathoms.

As a fossil it occurs in the Gault and Chalk (Parker and Jones), and in the Post-tertiary beds of the north-east of Ireland (Wright).

Gaudryina, d'Orbigny.

Gaudryina, d'Orbigny [1840], Reuss, Parker and Jones, Karrer, Stache, Schwager, Gümbel, Hantken, Brady, Wright, Norman, Marsson, Mártonfi, &c.
Sagrina, pars, d'Orbigny [1840].
Heterostomella, Reuss [1865].
Plectina, Marsson [1878].

The genus *Gaudryina* embraces a group of dimorphous *Textularinæ* which have the earlier segments arranged in a more or less regular triserial spire, and the later ones in two alternating series; in other words, those forms which are Verneuiline at the commencement, and subsequently Textularian in their mode of growth.

Von Reuss has attempted to confine the use of the term to the species that preserve the typical Textularian or marginal aperture, and places such as have a terminal orifice in a separate genus, *Heterostomella*. In dimorphous forms, generally speaking, the pseudopodial orifice is an even more variable feature than in the types from which they are derived, and that the genus *Gaudryina* is no exception to this rule may be seen by

[1] Mikrogeologie, pl. xxxii. II. fig. 26.

[2] Found on the north-east coast of England, and described under the name *Textularia complexa*, Brady, *Nat. Hist. Trans. Northd. and Durham*, 1865, vol. i. p. 101, pl. xii. fig. 6, *a.b.* A similar form from the Philippine Seas was subsequently figured by Ehrenberg, with the name *Spiroplecta demersa* (*Abhandl. d. k. Ak. Berlin*, for 1872, pl. vii. fig. 26).

the figures in Pl. XLVI., in some of which the aperture is a simple marginal fissure, like that of *Textularia* (proper), in others a bordered slit, either close to the margin or removed some distance from it, whilst in a few it appears as a bordered or tubulated orifice, still further displaced so as to be nearly central. In the present state of our knowledge there is little to be gained, either in precision or convenience, by placing in a separate genus the few variable and comparatively unimportant forms which present, in a greater or less degree, the latter peculiarity.

The minute structure of the test in *Gaudryina* exhibits nearly the same range of characters as that of the typical *Textulariæ*. The walls are seldom really hyaline or distinctly perforated, though in some species they are thin, homogeneous, and quite smooth; whilst in others they are thick, opaque, and calcareous, and in the remainder, more or less coarsely arenaceous, and rough externally.

The geographical distribution of the genus is world-wide. Its geological history commences with the Cretaceous period, when it was tolerably abundant, and is continued in various Tertiary formations down to recent times.

Gaudryina pupoides, d'Orbigny (Pl. XLVI. figs. 1–4).

Gaudryina pupoides, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. p. 44, pl. iv. figs. 22–24.
,, ,, Id. 1846, For. Foss. Vien., p. 197, pl. xxi. figs. 34–36.
,, *subglabra*, Gümbel, 1868, Abh. d. k. bayer Akad. Wiss., II. Cl., vol. x. p. 602, pl. i. fig. 4.

Gaudryina pupoides is an easily recognised species. Its dimorphous mode of growth is generally very apparent, and its variability is limited to such features as the number of segments, the relative length and breadth of the test, and the degree of lateral compression. In recent shells the walls are thin and calcareous, smooth externally, and almost invariably of a greyish hue; fossil specimens sometimes exhibit a slightly rough exterior. In form and position the aperture resembles that of the typical *Textulariæ*, but it is often surrounded by a raised lip or border.

Gaudryina pupoides is a common deep-water Foraminifer. The list of localities at which it has been found includes fourteen Stations in the North Atlantic, the most northerly being in about lat. 60° N., the depths ranging from 173 to 1780 fathoms; five Stations in the South Atlantic, 350 to 2350 fathoms; sixteen in the South Pacific, 129 to 2425 fathoms; and two in the North Pacific, 1850 fathoms and 2050 fathoms respectively.

In the fossil condition it is chiefly known as a Cretaceous species. The localities originally given by d'Orbigny were the Chalk of Meudon, Sens, St. Germain, and England; and to these Reuss has added various districts situated on the Chalk and Gault of North Germany. The *Gaudryina subglabra* of Gümbel, which may be referred to the same species, occurs in the Eocene formation of the Bavarian Alps.

Gaudryina pupoides, var. *chilostoma*, Reuss (Pl. XLVI. figs. 5, 6).

Textilaria chilostoma, Reuss, 1852, Zeitschr. d. deutsch. geol. Gesell., vol. iv. p. 18 (*fide* Reuss).
Gaudryina globulosa, Id. Ibid. p. 18 (*fide* Reuss).
Textilaria labiata Id. 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlii. p. 362, pl. ii. fig. 17, *a.–c.*
Plecanium labiatum, Id. 1863, Bullet. de l'Acad. roy. Belg., ser. 2, vol. xv. p. 139.
Gaudryina chilostoma, Id. 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 120, pl. i. fig. 5.

The *Gaudryina chilostoma* of Reuss differs from the typical *Gaudryina pupoides* in little except its compressed contour and more distinctly bordered aperture. The lateral edges are either rounded or subangular.

This variety occurs off Prince Edward Island, 50 to 150 fathoms; off Tahiti, 420 fathoms, and 620 fathoms; north of Juan Fernandez, 1375 fathoms; and in the South Atlantic, mid-ocean, 1425 fathoms.

The fossil specimens of *Gaudryina chilostoma* described by Reuss were from the Crag of Antwerp and the Septaria-clays of Germany. It is mentioned by Seguenza amongst the Foraminifera of the Upper Tertiaries of Calabria, and Hantken figures a very similar if not identical variety, which he names *Gaudryina textilaroides* (Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 15, pl. i. fig. 6), from the Middle Tertiaries of Hungary.

Gaudryina baccata, Schwager (Pl. XLVI. figs. 8–11).

Gaudryina baccata, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 200, pl. iv. fig. 12.
„ *uva*, Id. Ibid. p. 201, pl. iv. fig. 13.
„ *irregularis*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, p. 15, pl. i. fig. 7.

Under the name *Gaudryina baccata* are included certain wild-growing forms, which at first sight might be taken for monstrous examples of *Gaudryina pupoides*. They are characterised by distinct and generally much inflated segments, which are so combined as to produce a crooked or dislocated, or at least an irregular test. There is, however, a sort of method in the irregularity, very noticeable when a number of specimens are seen together, showing that it depends on something more than individual accident; and the distribution of the specimens favours the idea that they represent a tolerably definite local variety.

The occurrence of *Gaudryina baccata* has been recorded at seven points in the North Atlantic, at depths of 290 to 1750 fathoms; at one in the South Atlantic, 1900 fathoms; at two in the South Pacific, 210 and 2100 fathoms respectively; and at one in the North Pacific, 2300 fathoms.

The specimens originally described by Schwager were from the Pliocene deposits of Kar Nicobar, and similar examples are figured by Hantken from the *Clavulina-szabói* beds of Hungary.

Gaudryina subrotundata, Schwager (Pl. XLVI. fig. 13, *a.b.c.*).

Gaudryina subrotundata, Schwager, 1866, Novara-Exped., geol. Theil., vol. ii. p. 198, pl. iv. fig. 9, *a.b.c.*

„ *prælonga*, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 374, pl. xvi.*a*, fig. 6.

Schwager's figure of *Gaudryina subrotundata* represents a long, sub-cylindrical, somewhat compressed shell, less than a millimetre in length; whilst Karrer's drawing of *Gaudryina prælonga* is taken from a rough test, nearly circular in transverse section, and of much larger dimensions. They appear, however, to belong to the same species; one which, like many other *Textularinæ*, is subject to a good deal of variation, not only in the size and degree of compression of the test, but also in the texture of the walls. Recent specimens furnish almost every intermediate condition; that figured in Pl. XLVI. fig. 13, for example, presents characters just about midway between the two forms referred to. Karrer states that in one locality fossil specimens of *Gaudryina prælonga* attain a length of 4 mm.; living examples are not quite so large, but sometimes measure nearly 3 mm.

Gaudryina subrotundata occurs off Culebra Island, West Indies, 390 fathoms, and off Raine Island, Torres Strait, 155 fathoms, the specimens being much larger in the former than in the latter locality.

As a fossil it has been found in the Miocene beds of Baden near Vienna (Karrer), and in the Pliocene of Kar Nicobar (Schwager).

Gaudryina filiformis, Berthelin (Pl. XLVI. fig. 12, *a.b.c.*).

Gaudryina filiformis, Berthelin, 1880, Mém. Soc. géol. France., sér. 3, vol. i. No. 5, p. 25, pl. i. fig. 8.

„ „ Wright, 1882, Proc. Belfast Nat. Field Club (1880–1881), App. p. 180, pl. viii. figs. 3, 3 *a.b.*

This is a long slender variety, the dimorphous character of which is not always apparent at first sight. The triserial chambers are few in number and somewhat obscurely arranged, the Textularian segments very numerous and generally distinct. Tropical specimens often present the elegant contour shown in Pl. XLVI. fig. 12; in those from other sources the test is less attenuated and less neatly constructed.

Gaudryina filiformis has been taken at four Challenger Stations, namely:—off Sombrero Island and off Culebra Island, West Indies, 450 fathoms and 390 fathoms respectively; off Kandavu, Fiji, 610 fathoms, and off Tahiti, 620 fathoms and 420 fathoms. Small specimens have been collected in shallow water on the shores of Ireland and Scotland, by Messrs. Wright, Balkwill, and Robertson.

The examples originally described by Berthelin were from the Cretaceous system (Gault) of the north of France.

Gaudryina rugosa, d'Orbigny (Pl. XLVI. figs. 14–16).

Gaudryina rugosa, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. p. 44, pl. iv. figs. 20, 21.
„ „ Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 244, pl. vi. fig. 61, *a.b.*
„ „ Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 13, pl. i. fig. 4.

Gaudryina rugosa is sufficiently distinguished by the large development and triangular contour of the triserial portion of the test, and by the rough arenaceous texture of the walls.

In the living condition it has been noticed at seven localities, namely:—Vigo Bay, Spain, 11 fathoms; off Pernambuco, 675 fathoms; Simon's Bay, South Africa, 150 fathoms; and four Stations in the South Pacific, 38 to 210 fathoms, the finest specimens being from off Raine Island, Torres Strait, 155 fathoms.

It is a common fossil of the later Mesozoic formations, occurring in various deposits of the Cretaceous period, in France, Germany, Bohemia, England, and Ireland (d'Orbigny, Reuss, Wright). It is found also in beds of Middle Tertiary age in Germany and Hungary (Reuss, Hantken).

Gaudryina scabra, n. sp. (Pl. XLVI. fig. 7, *a.b.*).

Gaudryina pupoides, Brady, 1870, Ann. and Mag. Nat. Hist., ser. 4, vol. vi. p. 300, pl. viii. fig. 5.

Test elongate, tapering, somewhat compressed; oral end broad and rounded, aboral extremity narrow, and obtusely pointed; lateral edges thick and rounded. Triserial portion small but distinct; biserial segments numerous, about five in each row, slightly inflated; aperture a simple arched fissure at the inner margin of the final segment, on its line of union with the penultimate. Texture arenaceous; colour brown. Length, $\frac{1}{12}$th inch (2 mm.).

This, when well developed, is a large and striking variety, not differing materially in general contour from *Gaudryina pupoides*, but readily distinguished by the brown colour and rough arenaceous structure of the walls. The aperture is a simple Textularian fissure, without lip or border.

In a paper on brackish-water Foraminifera, published several years ago (*loc. cit.*), I figured, under the name *Gaudryina pupoides*, a minute thin-shelled arenaceous specimen obtained from Montrose Basin, which there can be little doubt is a starved example of the present species.

Gaudryina scabra has only been taken at two Challenger Stations, not far apart, namely:—off Sombrero Island, 450 fathoms, and off Culebra Island, 390 fathoms.

Gaudryina siphonella, Reuss (Pl. XLVI. figs. 17–19).

Gaudryina siphonella, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesell., vol. iii. p. 78, pl. v. figs. 40–42.
Textilaria reussi, Speyer, 1864, Die Tertiär-Fauna von Söllingen, p. 83 (*fide* Reuss).
Gaudryina siphonella, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 463, No. 1,— Schlicht, 1870, Foram. Pietzpuhl, pl. xxiv. figs. 26–29.
" " Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt., vol. iv. p. 14, pl. i. fig. 3.
Plectina clava, Marsson, 1878, Mittheil. naturw. Vereine v. Neu-Vorpom. u. Rügen, Jahrg. x., p. 160, pl. iii. fig. 29 *a.–d.*

The original figures of *Gaudryina siphonella* (*loc. cit.*) are probably somewhat idealised, as they represent a test constructed with a diagrammatic regularity seldom encountered amongst dimorphous Foraminifera; von Schlicht's drawings, allotted by Reuss to the same species, suggest, on the other hand, extreme irregularity of contour. Something between the two is the more common condition; and the elongate, subcylindrical, somewhat tapering tests, with inflated segments, and projecting terminal apertures, well portrayed in Pl. XLVI. figs. 17–19, sufficiently illustrate the typical features of the species. Recent specimens are generally minute and inconspicuous, but they vary a good deal as to size, and may be found from $\frac{1}{80}$th to $\frac{1}{28}$th inch (0·3 to 0·9 mm.) in length.

Though comparatively rare in the living condition, *Gaudryina siphonella* is very widely distributed. It has been observed at three points in the North Atlantic, at two in the South Atlantic, at three in the North Pacific, and at five in the South Pacific. It appears to prefer deep water, for of the thirteen Stations above enumerated, six have a depth of more than 2000 fathoms, one being in the deepest part of the North Pacific, 3950 fathoms; whilst four are between 1000 and 2000 fathoms; and only three at less than 1000 fathoms.

As a fossil it has been collected by Reuss and Schlicht in the Septaria-clays of North Germany, and by Hantken in the Lower *Clavulina-szabói* beds of Hungary. The somewhat obscure fossils figured by Marsson (*loc. cit.*) from the Cretaceous formation of the Island of Rügen appear to be nothing more than irregular specimens of the same species.

Verneuilina, d'Orbigny.

Textularia, pars, Münster [1838], Reuss, Bailey, Parker and Jones, Fischer.
Verneuilina, d'Orbigny [1840], Reuss, Costa, Karrer, Parker and Jones, Brady, M. Sars, Terquem, Robertson, Winther, Wright, Marsson, Berthelin, &c.
Bulimina, pars, Reuss [1846], Alth, Egger, Williamson, Parfitt.
Polymorphina, Schultze [1854].
Rhynchospira, Hantken [1875].
Reussia, Schwager [1877].

The genus *Verneuilina* was devised by d'Orbigny for the regular triserial *Textularinæ*, typified by the Cretaceous *Verneuilina tricarinata;* and with some limitation as

to the nature of the aperture, the term is still employed in the original sense. Two subordinate groups of triserial forms have since been established, *Chrysalidina* and *Tritaxia*, the former for those with porous aperture, the latter for such as have a single, round, central orifice; leaving to *Verneuilina* the larger series, in which the aperture more or less resembles that of the typical *Textulariæ*.

The minute structure of the test varies in precisely the same manner and to the same extent as that of *Textularia* proper. The walls are either coarsely arenaceous, as in *Verneuilina polystropha*, finely arenaceous and smooth externally, as in *Verneuilina pygmæa*, or hyaline and conspicuously perforate, as in *Verneuilina spinulosa*. Under the name *Rhynchospira abnormis*, von Hantken has figured (Mittheil. Jahrb. d. k. ung. geol. Anstalt, p. 69, pl. vii. figs. 17–19) an interesting modification of *Verneuilina*, in which the exterior is ornamented by a number of minute tubercles, scattered with some regularity over a portion, or in some cases over the whole, of the surface of the shell.

In the typical condition the test is triangular in contour, and the margins are thin or subcarinate; but in those species in which the segments are inflated or subglobular, it takes the form of a rounded triserial spire, slightly compressed on three sides.

No limits can be laid down for the geographical or bathymetrical distribution of the genus; the different species affect different conditions of latitude and depth, and in one or other of its various modifications it is found over the whole world. Its earliest, appearance, geologically speaking, is in rocks of the Cretaceous period, and its occurrence is recorded in microzoic formations of almost every subsequent age.

Verneuilina triquetra, Münster, sp. (Pl. XLVII. figs. 18–20).

Textularia triquetra, Münster, 1838 (in Römer's paper), Neues Jahrb. für Min.,&c., p. 384, pl. iii. fig. 19.
„ „ Reuss, 1845, Verstein. Böhm. Kreid., pt. 1, p. 39, pl. xiii. fig. 77.
„ *atlantica*, Bailey, 1851, Smithsonian Contrib., vol. ii. art. 3, p. 12, figs. 38–42.
„ (*Verneuilina*) *triquetra*, Parker and Jones, 1863, Ann. and Mag. Nat. Hist., ser. 3, vol. xi. p. 92.

The original drawings of this species accompanying Römer's memoir are very small and ill defined, and those given by Reuss some years later are not much more serviceable as a means of identification. So far as can be gathered, both authors intended to portray an organism with the general contour and structure of that represented in Pl. XLVII. fig. 19. The precise shape, however, is not of great moment, for the species resembles other Textularians in the variability of its external aspect, the same locality furnishing long slender specimens like fig. 20, and short pyramidal forms such as that already referred to. The test is arenaceous, the exterior generally rugose; sometimes sponge-spicules are used in conjunction with sand as building material, and the angular

margins bristle with their projecting ends, as in fig. 19. The test frequently attains a large size, and may be said to range from $\frac{1}{25}$th to $\frac{1}{6}$th inch (1 to 4 mm.) in length.

Verneuilina triquetra is by no means common in the living condition. The finest Challenger specimens are from Stations 24, off Culebra Island, West Indies, 390 fathoms; smaller but characteristic examples occur in two soundings off Kandavu, Fiji Islands, at depths of 210 fathoms, and 255 fathoms respectively. The species is excellently figured by Bailey, from specimens dredged on the coast of North America, south-east of New York, 89 fathoms.

It is well known as a Cretaceous fossil, having been found in the Chalk of the south-east of England (Ehrenberg, Eley, Parker and Jones), and of Bohemia (Reuss). It occurs also in the Tertiary Sands of North Germany (Römer).

Verneuilina spinulosa, Reuss (Pl. XLVII. figs. 1–3).

Verneuilina spinulosa, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 347, pl. xlvii. fig. 12, *a.–c.*
" *spinosissima*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 263, pl. xxiii. fig. 5, *A. C.*
" *spinulosa*, Egger, 1857, Neues Jahrb. für Min. &c., p. 292, pl. ix. figs. 17, 18.
" " Brady, 1870, Ann. and Mag. Nat. Hist., ser. 4, vol. vi. p. 301, pl. xii. fig. 6, *a.–c.*

This is a tricarinate species, in which the marginal angle of each segment terminates in a projecting spine, the point of which is directed towards the aboral end of the test. The shell is broadest near the oral end, and tapers to a point at the opposite extremity; it is calcareous and hyaline, and generally conspicuously perforated.

In the living condition, *Verneuilina spinulosa* is best known as a tropical or sub-tropical shallow-water form. In the Atlantic it is exceedingly rare. Isolated specimens have been collected, both by Mr. Siddall and myself, on our own shores, and it has been dredged off Bermuda, at a depth of 435 fathoms, but it has not been noticed elsewhere in the North Atlantic; and south of the Equator it appears to be equally scarce, the single recorded locality being Station 122, south-east of Pernambuco, 350 fathoms. It has been observed in the Mediterranean, in the Red Sea, and on the coast of Mauritius and Ceylon; at twelve Stations in the South Pacific, 12 fathoms to 1100 fathoms; and at four in the North Pacific, 7 fathoms to 2300 fathoms. The greater depths referred to are quite exceptional; in a list comprising twenty-four localities only seven exceed 100 fathoms.

As a fossil this species has been obtained from the Chalk of the south-east of England (Ehrenberg, *fide*, Parker & Jones), from the Miocene formations of Austria (Reuss, Karrer), of Bavaria (Egger), and of Malta (Brady); from the Pliocene of Italy (Costa, Parker and Jones), and of Spain (Parker and Jones); and from the Post-tertiary beds of the Island of Ischia (Vanden Broeck).

Verneuilina variabilis, n. sp. (Pl. XLVII. figs. 21–24).

Typical form, fig. 23 *a*. *b*.—Test free, triquetrous; oblong, broadest near the oral end, and tapering somewhat towards the aboral extremity; compressed and concave on three sides, the three salient edges thin and slightly rounded; margins lobulated, incised, or irregular. Segments numerous, irregularly triserial; septation often obscure. Aperture an elongate fissure at the margin of the final segment, generally nearly central. Texture coarsely arenaceous, exterior rough. Length, $\frac{1}{8}$th inch (3 mm.).

The above description conveys the characters of what may be regarded as the typical condition of this polymorphic species,—that in which its affinity to *Verneuilina triquetra* and other allied forms is most clearly recognised. Of the numberless modifications of the typical structure, the most common are such as those represented by fig. 24, in which the test is more or less quadrate, and by figs. 21 and 22, in which it loses to some extent its ternate character in the other direction, and presents during part of its growth only two marginal edges. No specific or even varietal distinction can be drawn between these forms; and in the locality whence the specimens were obtained, every intermediate condition is common.

Dr. Schwager has proposed a distinct genus, *Reussia*, for the varieties of *Verneuilina* which have the slit-like aperture noticed in the present species, not having perceived, pparently, how little it differs in reality from the ordinary Textularian orifice.

Verneuilina variabilis is found associated with *Verneuilina triquetra* in the coral-sands of Kandavu, Fiji Islands, at a depth of 210 fathoms.

Verneuilina pygmæa, Egger, sp. (Pl. XLVII. figs. 4–7).

Bulimina pygmæa, Egger, 1857, Neues Jahrb. für Min., &c., p. 284, pl. xii. figs. 10, 11.
Verneuilina pygmæa, Parker and Jones, 1863, Ann and Mag. Nat. Hist., ser. 3, vol. xi. pp. 92, 98.
Textilaria triseriata, Terquem, 1882, Mém. Soc. géol. France, ser. 3, vol. ii. Mém. III. p. 145, pl. xv. fig. 10.

It is probable that Parker and Jones are right in referring the *Bulimina pygmæa* of Egger to the genus *Verneuilina*; and if so, the specimens portrayed in Pl. XLVII. figs. 4–6, must be assigned to that species. Nevertheless it would have been more satisfactory had the author, either in his description or in the drawings accompanying it, indicated with greater clearness the minute characters of the shell, and especially of its aperture.

The test of *Verneuilina pygmæa* differs from that of *Verneuilina polystropha* in the compact and very finely arenaceous texture of the walls, its nearly white colour, and smooth exterior; and in the aperture, which is an elongate, arched fissure bordered by a raised lip.

Under the name *Verneuilina rotundata*, Dr. Karrer has figured a shell with similar general features, which probably belongs to the same species (Drasche's "Insel Luzon," p. 85, pl. v. fig. 2).

Verneuilina pygmæa is a common deep-water Foraminifer, its area of distribution extending from about lat. 60° N. to the Antarctic Ice-barrier. It has been observed at fourteen Stations in the North Atlantic, at depths ranging from 420 to 2750 fathoms; at six in the South Atlantic, 675 to 2475 fathoms; at four in the Southern Ocean, 1300 to 1950 fathoms; at twelve in the South Pacific, 129 to 2375 fathoms; and at six in the North Pacific, 1850 to 3125 fathoms. Of these forty-two localities, only eight have a depth of less than 1000 fathoms, and fourteen are above 2000 fathoms.

Little can be said of the occurrence of the species in the fossil state. Parker and Jones think that it may be recognised amongst Ehrenberg's figures of Foraminifera from the Chalk of Meudon in France, and of the Island of Möen, in Denmark. Egger's specimens were obtained from the Miocene beds of Lower Bavaria, and Karrer's (*Verneuilina rotundata*) from a Tertiary clay in the Island of Luzon, Philippines.

Verneuilina polystropha, Reuss, sp. (Pl. XLVII. figs. 15–17).

Bulimina polystropha, Reuss, 1845, Verstein. Böhm. Kreid., pt. 2, p. 109, pl. xxiv. fig. 53.
Polymorphina silicea, Schultze, 1854, Organism. Polythal., p. 61, pl. vi. figs. 10, 11.
Bulimina scabra, Williamson, 1858, Rec. For. Gt. Br., p. 65, pl. v. figs. 136, 137.
,, *arenacea*, Id. Ibid. p. 98.
Verneuilina polystropha, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
Textularia agglutinans, var. (*Verneuilina*) *polystropha*, Id. 1865, Phil. Trans., vol. clv. p. 371, pl. xv. fig. 26.
,, *scabra*, Fischer, 1870, Actes. Soc. Linn. Bordeaux, vol. xxvii. p. 393, No. 32.
Verneuilina polystropha, Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 436, pl. xx. fig. 9, *a.–c.*

Since the publication of Carpenter's "Introduction," the name *Verneuilina polystropha* has been very generally adopted for a small arenaceous, *Bulimina*-like Foraminifer, well known by Schultze's, and still better by Williamson's figures.

In recent specimens of this species the test is coarsely arenaceous, and rough externally, but it is generally thin and fragile, and seldom exceeds $\frac{1}{40}$th inch (0·63 mm.) in length. I have had no opportunity of comparing living and fossil specimens, and am unable to say whether those of Cretaceous age agree more closely with this or with the allied, but much larger, deep-water variety, described under the name *Verneuilina propinqua*.

Verneuilina polystropha is seldom met with at a greater depth than 50 fathoms, and it most affects muddy bottoms of less than 10 fathoms, littoral sands, and shallow estuaries. It has been found as far north as Novaya Zemlya, Baffin's Bay, and Davis Strait, and is common on the shores of Great Britain, Denmark, France, and Spain; in the Mediterranean and the Adriatic. It has also been taken on the coast of Ceylon, and at Port Jackson, Australia.

Of its occurrence in the fossil condition little can be said except that it appears in

the lists of the Post-tertiary Foraminifera of Norway (Sars), of the west of Scotland (Robertson), and of the north-east of Ireland (Wright).

Verneuilina propinqua, n. sp. (Pl. XLVII. figs. 8–14).

Test free or adherent, triquetrous, compressed on three sides; broad and rounded at the oral end, tapering to a blunt point at the aboral extremity; lateral edges rounded. Segments numerous, distinct, inflated; sutures depressed; aperture Textularian. Walls thick, arenaceous, firmly cemented; colour brown. Length of large specimens sometimes $\frac{1}{7}$th inch, 3·6 mm.

It is difficult to define the precise relationship between this form and the species last described. The general morphological characters of the two are exceedingly similar, but the test in the present case is, comparatively speaking, of very large size, it has thick and firmly cemented walls, and betrays a tendency to an adherent habit of growth. It may be that the two represent only shallow-water and deep-water varieties of the same species, but there is no good evidence of the fact, either in the occurrence of shells with intermediate characters or of specimens from intermediate depths. Such examples of *Verneuilina polystropha* as have been found at a greater depth than fifty fathoms retain the normal peculiarities of the shallow-water variety. At any rate, so far as at present known, the two forms are sufficiently well characterised for easy recognition, and I have therefore accorded to the larger type an independent position and a distinctive name.

Verneuilina propinqua has been observed at five Stations in the North Atlantic, of which one is at a depth of 100 fathoms, the other four ranging from 1000 to 2435 fathoms; at one Station in the South Atlantic, 1900 fathoms; at one in the South Pacific, 610 fathoms; and at three in the North Pacific, 95 fathoms, 2050 fathoms, and 2900 fathoms respectively. Nothing is known of its occurrence in the fossil condition.

Chrysalidina, d'Orbigny.

Chrysalidina, d'Orbigny [1846], Carpenter, Brady, Bütschli.

The genus *Chrysalidina* was established by d'Orbigny for a type of fossil Foraminifera found by him in the Cretaceous beds of the mouth of the Charente, on the west coast of France. The single species assigned to it, *Chrysalidina gradata*, is described and figured in the "Vienna Basin" memoir p. 194 (pl. xxi. figs. 32, 33), and was apparently to have been included in the unpublished 5th Livraison of the author's models of Foraminifera. The figures referred to represent a tapering, triserial, Textularian shell, nearly circular in transverse section, with somewhat numerous short segments

regularly superimposed, and with an aperture consisting of a large number of pores scattered over the convex distal end of the test. Generically it is only distinguished from *Verneuilina* by the porous aperture. There appears to be no record of the occurrence of this species, beyond that supplied in the original notice.

Chrysalidina dimorpha, H. B. Brady (Pl. XLVI. figs. 20, 21).

Chrysalidina dimorpha, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 54.

Test elongate, triangular, tapering; the three sides nearly equal, the angles subcarinate; inferior extremity pointed, distal end broad and slightly convex. Segments numerous, arranged triserially at the commencement, subsequently in single series. Aperture consisting of a number of minute perforations on the distal face of the terminal chamber. Texture hyaline. Length, $\frac{1}{50}$th inch (0·5 mm.).

This species differs from the type (*Chrysalidina gradata*) in two particulars,—the test is triangular instead of nearly round in transverse section, and the arrangement of the segments is dimorphous instead of being triserial throughout. The early segments however are distinctly Verneuiline, and the aperture is conspicuously porous.

Chrysalidina dimorpha is a rare Foraminifer, inhabiting comparatively shallow water in the tropics. It has been found on the coral-reefs of Honolulu, 40 fathoms; in Hong Kong harbour, 7 fathoms; in dredged sand from Torres Strait, off Raine Island, 155 fathoms; and in shore-sands from the east coast of Madagascar. A long, somewhat attenuated variety occurs in the last-named locality, and also in shallow water on the coast of Ceylon.

Tritaxia, Reuss.

Uvigerina, pars, d'Orbigny [1840].
Textularia, pars, Reuss [1845].
Verneuilina, pars, Reuss [1850], Parker and Jones.
Tritaxia, Reuss [1860], Wright, Marsson, Brady, Terquem.
Clavulina, pars, Brady [1881].

The genus *Tritaxia* includes those triserial modifications of *Textularia* which differ from *Verneuilina* in having a central aperture. The aperture generally speaking takes the form of a simple rounded perforation. Such varieties betray the same tendency as *Chrysalidina* to produce dimorphous varieties.

In the living condition *Tritaxia* is extremely rare, and its distribution limited to a few localities. It is best known by the Cretaceous species, described under various generic names by d'Orbigny, Reuss, and others.

Tritaxia lepida, H. B. Brady (Pl. XLIX. fig. 12, *a.b.*).

Tritaxia lepida, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 55.
„ *ovata*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III., p. 105, pl. xi. fig. 11.

Test triquetrous; elongate, broadest near the middle, tapering to a point at the aboral extremity, distal end rounded; the three sides nearly equal, the angles sharp or subcarinate; texture hyaline. Aperture simple, consisting of a short tubular neck with thickened lip, at the centre of the terminal segment. Length, $\frac{1}{80}$th inch (0·3 mm.).

This rare and delicate little shell, distinguished by its hyaline texture and central tubular aperture, was found at Station 45, off the coast of North America, a little south of the latitude of New York; depth, 1240 fathoms.

The *Tritaxia ovata* of Terquem, from the Eocene beds of the environs of Paris, appears to belong to the same species.

Tritaxia tricarinata, Reuss (Pl. XLIX. figs. 8, 9).

Textularia tricarinata, Reuss, 1845, Verstein. Böhm. Kreid., pt. i., p. 39, pl. viii. fig. 60.
Verneuilina dubia, Id., 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 40, pl. iv. fig. 3.
Tritaxia tricarinata, Id., 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xl. p. 228, pl xii. figs. 1, 2.

I find no characters by which recent specimens, such as those represented in Pl. XLIX. figs. 8, 9, can be distinguished from the Cretaceous species as delineated by Reuss. In the form and disposition of the segments and the obscure septation they resemble the drawings of *Verneuilina dubia* in the "Lemberg" memoir (*loc. cit.*), rather than the better-defined figures subsequently published; but these minor characters are rightly treated by the author in his later papers as the result of mere individual variation.

Living specimens of *Tritaxia tricarinata* have only been found at a single Challenger Station, off Raine Island, Torres Strait, 155 fathoms.

The works above quoted refer to the occurrence of the species in the Upper Cretaceous system (Cenomanian, Senonian, &c.) of Germany and Bohemia.

Tritaxia indiscreta, H. B. Brady (Pl. XLIX. figs. 10, 11).

Clavulina indiscreta, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 55.

Test triquetrous; compressed on three sides, broadest near the middle, tapering towards the ends; salient edges rounded, except near the aboral end, where they are

angular and sharp; oral end rounded or obtuse, opposite extremity more or less pointed. Segments comparatively few, septation very obscure externally. Texture subarenaceous, compact; surface smooth; colour dirty-white. Aperture a neat, round, terminal orifice. Length, about $\frac{1}{16}$th inch (1·6 mm.).

In the provisional description of this species (*loc. cit.*), it was erroneously referred to the genus *Clavulina*. It is a near ally of *Tritaxia tricarinata*, from which it differs somewhat in size, contour, and other minor particulars, but chiefly in the substance and texture of the test. The walls are thick and calcareous, and though not quite homogeneous, are nearly smooth externally, and have but little appearance of arenaceous structure.

The specimens were dredged at Station 174, off Kandavu, Fiji Islands, 210 fathoms.

Tritaxia caperata, H. B. Brady (Pl. XLIX. figs. 1–7).

Clavulina caperata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 54.

Test dimorphous, the earlier or broader portion triserial (Verneuiline), the later segments of adult specimens more or less uniserial: subcylindrical or elongate-ovate in contour; oral end narrow, either rounded or truncate; aboral end tapering to a point, or slightly rounded. Segments very numerous, short, irregular in form, cavities subdivided by secondary septa; sutures marked by limbate lines, which give the exterior of the test a transversely wrinkled appearance. Aperture simple; in adult specimens central and terminal, often partially closed by an irregular projecting border. Length, $\frac{1}{10}$th inch (2·5 mm.).

This species was originally assigned to the genus *Clavulina*, under the impression that the contracted apertural border, noticed in adult specimens, was some modification of the "valvular tongue," which is a distinctive feature of that type. But in the earlier or triserial stage of growth (fig. 3, *a.b.*), the orifice is distinctly Textularian, not Valvuline; and this fact, together with the subdivided chambers, leaves little doubt that the species is in reality a modification of *Verneuilina*, and may therefore, from its central aperture, be treated as a dimorphous form of *Tritaxia*.

The walls of the test are thick and finely arenaceous, and in some places are traversed by long pore-canals, as shown in fig. 7. The labyrinthic condition of the interior is illustrated by the sectional figures, 4, 5, 6.

The best examples of *Tritaxia caperata* have been procured from sands dredged off Kandavu, Fiji Islands, 250 fathoms; but the species also occurs off the Philippine Islands, 95 fathoms, and sparingly off Sombrero Island, West Indies, 450 fathoms.

Valvulina, d'Orbigny.

Valvulina, d'Orbigny [1826], Münster, Bronn, Reuss, Parker and Jones, Karrer, Carpenter, Brady, M. Sars, Robertson, Schulze, Berthelin, &c.
Tetrataxis, Ehrenberg [1854], Möller, Schwager.
Rotalina, pars, Williamson [1858], Parfitt, Terquem.

Valvulina triangularis, the species portrayed in d'Orbigny's Model No. 25, has been selected by Parker and Jones as the type of a large group of closely-related Foraminifera. The model in question represents a triserial shell, compressed on three sides, and with sharp salient angles, broad and somewhat rounded at the oral end, and tapering to a point at the opposite extremity, the aperture, which is situated on the inner margin of the final segment, being partially covered by a projecting flap or valve.

Modifications of this typical structure take place in two directions. On the one hand, the test, whilst preserving the normal arrangement of the chambers and the characteristic aperture, loses its angular contour and becomes conical or even plano-convex, producing forms like *Valvulina conica* and *Valvulina fusca;* and a further slight deviation from the type occurs in certain fossil species of Palæozoic age, which frequently exhibit more than three segments in each whorl.

On the other hand, the typical structure modified in the opposite direction, that is to say, becoming elongated and columnar instead of widening laterally, furnishes a series of dimorphous forms, in which the earlier chambers preserve the normal triquetrous arrangement, whilst the later ones are disposed in a uniserial line. These varieties, which constitute the subordinate genus *Clavulina*, assert their relationship by retaining the valvular aperture even in the uniserial segments.

The test of *Valvulina* is invariably more or less arenaceous; but unlike that of the Lituolidæ, it often possesses a well-defined, perforate, shelly basis or lining, which is sometimes exposed to view where the exterior has been abraded. The same sort of structure has already been referred to in connection with the allied genus *Textularia*.

The geographical distribution of the genus *Valvulina* is exceedingly wide, in fact the type is met with, in one form or other, in all the great oceans, though seldom at depths of more than five or six hundred fathoms. In the fossil condition it dates back as far as the Carboniferous epoch, having furnished one of the most important groups of minute Foraminifera occurring in the limestones of that age; but it is better known as a Tertiary genus, conspicuous in the Eocene deposits of Grignon and Hauteville.

Valvulina conica, Parker and Jones (Pl. XLIX. figs. 15, 16).

Valvulina triangularis, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 295, pl. xi. figs. 15, 16.
„ *triangularis*, var. *conica*, Id. 1865, Phil. Trans., vol. clv. p. 406, pl. xv. fig. 27.
„ *conica*, M. Sars, 1868, Vidensk.-Selsk. Forhandl., p. 249.

This species differs from the typical *Valvulina triangularis* chiefly in the absence of trifacial compression. The test is conical, and so far as the arrangements of the chambers is concerned it is triquetrous ; but the oral end is circular and nearly flat. The aperture is at the umbilical margin of the final segment, almost concealed by the overhanging valvular lip

Valvulina conica is essentially a parasitic species, and it not unfrequently occurs in colonies like that represented in fig. 16. When found *in situ*, the test is generally surrounded by a spreading mass of fine light-coloured sand, apparently collected by the animal as a protection for the sarcode protruded from the base of the test (figs. 15, 16). The sand is of even grain, and though sufficiently coherent to bear washing in a stream of water, the mass is easily disintegrated with a camel's-hair pencil. This sandy rampart is quite distinct from the test itself, and differs from it both in colour and texture ; but it is more than probable that the material for the construction of the test, as it increases in size, may be selected from what is accumulated in this way. Adherent specimens of *Valvulina fusca* are generally surrounded in a similar manner (fig. 14). The test of the present species is brown in colour, darkest at the apex, and gradually becoming lighter towards the oral end.

Valvulina conica is common on the coast of Norway, at 100 to 450 fathoms, and occurs at similar depths in the Faröe Channel, and the Gulf of St. Lawrence. It has been observed at three Challenger Stations in the South Pacific, namely:—off Kandavu, Fiji, 210 fathoms; off Raine Island, Torres Strait, 155 fathoms; and off Juan Fernandez, 1375 fathoms. Parker and Jones report its presence in the Mediterranean, 320 fathoms ; on the Abrolhos Bank, 47 fathoms ; and in shore-sands from Melbourne, Australia.

Valvulina fusca, Williamson, sp. (Pl. XLIX. figs. 13, 14).

Rotalina fusca, Williamson, 1858, Rec. For. Gt. Br., p. 55, pl. v. figs. 114–115.
Valvulina triangularis, var. *austriaca*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
Valvulina austriaca, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 472.
„ *fusca*, M. Sars, 1868, Vidensk.-Selsk. Forhandl., p. 249.
Rotalina fusca, Terquem, 1875, Anim. sur la Plage de Dunkuerque, p. 26, pl. ii. fig. 6, *a.b.*
Valvulina fusca, Berthelin, 1878, Foram. de Bourgneuf et Pornichet, p. 25, No. 21.

Valvulina fusca differs from *Valvulina conica* principally in the low depressed plano-convex form of the test. Like the latter species it is of parasitic habit, but the test is

more easily detached, and specimens in the adherent condition are not very frequently met with. The accumulation of sand surrounding adherent specimens has already been described in connection with the allied form.

Valvulina fusca is a common North Atlantic Foraminifer. It most affects comparatively shallow water, though it has been taken at depths as great as 500 or 600 fathoms. It occurs on the shores of Norway, Great Britain, Belgium, and France, the Canary Islands, the Azores, and the West Indies. I have no record of its presence in the South Atlantic; but in the South Pacific it has been observed at five localities, the depths ranging from 7 to 410 fathoms; and in the North Pacific at a single point, off the Philippine Islands, 95 fathoms. The species is not known in the fossil condition.

Clavulina, d'Orbigny.

Spirolinites, pars, Lamarck [1804].
Nodosaria, pars, Lamarck [1816], d'Orbigny, Morris.
Clavulina, d'Orbigny [1826], Münster, Bronn, Reuss, Costa, Karrer, Seguenza, Stache, Schwager, Gümbel, Hantken, &c.
Orthocerina, d'Orbigny [1826].
Verneuilina, pars, Parker and Jones [1860], Vanden Broeck.
Valvulina, pars, Parker, Jones, and Brady [1865].

The genus *Clavulina* bears precisely the same relation to *Valvulina* that *Bigenerina* bears to *Textularia*; that is to say, it is a dimorphous modification, the earlier segments of which are arranged in the typical manner as a triserial spire, whilst the later chambers are disposed in a single Nodosariform line. In recent specimens the relationship to *Valvulina* may almost invariably be recognised by the aperture, which, even in the dimorphous varieties, retains the normal character, and is partially closed by a projecting tongue or valve.

Two other genera of *Textularidæ*, namely, *Chrysalidina* and *Tritaxia*, have dimorphous modifications resembling *Clavulinæ*; and though there are minor differences by which such forms may be distinguished, the nature of the aperture affords as a rule the safest means of identification. Thus in *Chrysalidina* the aperture consists of a number of small pores, in *Tritaxia* it is a simple rounded opening, and in *Clavulina* it is a circular orifice with an overhanging valvular tongue.

The walls of the test are thick and finely arenaceous, as shown in the various sectional drawings in Plate XLVIII., the constituent sand-grains being often almost entirely calcareous. Less frequently the test is composed of coarse sand, and presents a rough exterior. Sometimes a more or less complete shelly lining may be traced, and the rim surrounding the orifice is nearly always of fine homogeneous texture and smoothly finished.

In the northern hemisphere the distribution of the genus *Clavulina* is somewhat limited, and does not extend much to the north of lat. 40° N., either in the Atlantic or

the Pacific Ocean; but in the southern hemisphere it is found at all latitudes, from the equator to the Antarctic Ice-barrier.

The genus makes its earliest appearance near the beginning of the Tertiary epoch, and from the Eocene period to the present time it is represented in microzoic rocks of almost every geological age.

Clavulina communis, d'Orbigny (Pl. XLVIII. figs. 1–13).

Clavulina communis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 268, No. 4.
„ „ Id. 1846, For. Foss. Vien., p. 196, pl. xii. figs. 1, 2.
Verneuilina communis, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 303, No. 82.
Clavulina communis, Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 393, No. 33.
Verneuilina communis, Vanden Broeck, 1876, Ann. Soc. Belg. Micr., vol. ii. p. 136, pl. iii. fig. 14.

The earlier segments of *Clavulina communis* are spiral and triquetrous, and form collectively a more or less pointed cone, round in transverse section, not angular as in *Clavulina parisiensis*. In much elongated specimens the triserial portion is broader than the uniserial segments immediately succeeding it, but this is not the case in shells of stouter build. The chambers of the linear series vary in number from two or three to twenty or more, and in the attenuated forms they gradually increase in diameter towards the distal end; the sutures are generally distinct, but only slightly excavated externally. The test is finely arenaceous, often built of calcareous rather than siliceous sand, and tolerably smooth externally. It presents a wide range in point of size, adult recent specimens varying in length from $\frac{1}{30}$th to $\frac{1}{5}$th inch (0·84 to 5·0 mm.).

M. Paul Fischer (*loc. cit.*), on the authority of de Folin, records the occurrence of *Clavulina communis* in the Bay of Biscay. The precise locality is not stated, but assuming it to be in the neighbourhood of Bayonne (say about lat. 43° N.), this is the northern limit, not only of the species, but, so far as at present known, of the genus. Beyond this latitude in the North Atlantic, its place appears to be occupied by the allied and in many respects similar type *Bigenerina*. In the Pacific the species has not hitherto been found further north than lat. 36° N. The Challenger collections furnish specimens from four Stations in the North Atlantic:—off the Canaries, off Sombrero and Culebra Islands in the West Indies, and off Bermuda, the depths varying from 390 to 620 fathoms; from three Stations in the South Atlantic, 350 to 2200 fathoms; from four in the Southern Ocean, reaching as far south as the Antarctic Ice-barrier, lat. 65° 42′ S., depth 1675 fathoms; from fifteen in the South Pacific, 147 to 1375 fathoms; and from two in the North Pacific, 345 and 2300 fathoms respectively. The area of distribution includes also the Mediterranean and the Adriatic.

The species is likewise common in the fossil condition, occurring freely in the microzoic rocks of almost the whole Tertiary system. It has been recorded from the Eocene beds of the south of France (d'Orbigny), and of the London Basin (Parker and Jones, Brady); the Septaria-clays of Germany, and the Salt-clay of Galicia (Reuss); the Miocene of various ages in many parts of Austria and Hungary (Reuss, Karrer, Hantken); and the Pliocene of Italy (d'Orbigny).

Clavulina parisiensis, d'Orbigny (Pl. XLVIII. figs. 14–18).

Clavulina parisiensis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 268, No. 3;—Modèle, No. 66.
Valvulina parisiensis, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. pp. 29, 35, pl. i. fig. 26.

Clavulina parisiensis differs from *Clavulina communis* in the distinctly triangular contour of the triserial or primordial portion of the test, but in other respects the two species are very similar. The uniserial chambers are sometimes more or less inflated or even moniliform, and the test is often, though not invariably, coarsely arenaceous and rough externally.

In both the recent and fossil states, this species is much less common than *Clavulina communis*. It has only been observed at twelve Challenger Stations, all of which, with a single exception, have depths of less than 600 fathoms. They are as follows:—in the North Atlantic, off Culebra Island, 390 fathoms; off Bermuda, 435 fathoms; and off the Azores, 450 fathoms: in the South Atlantic, off Pernambuco, 350 fathoms: in the North Pacific, off the Philippine Islands, 95 fathoms; and at Station 253, in the very deep area, 3125 fathoms: lastly, at six Stations in the South Pacific, ranging in depth from 7 fathoms to 580 fathoms.

The specimens originally described by d'Orbigny were fossils from the Lower Tertiary beds of the neighbourhood of Paris, and the form is tolerably plentiful in the London Clay, near Clapham Common; but I am not aware that it has been found in later formations.

Clavulina parisiensis, var. *humilis*, nov. (Pl. XLVIII. figs. 19–21).

This is a small, feeble, local variety, which has only been observed off the Philippine Islands, at a depth of 95 fathoms. The test is thin, but somewhat rough externally. It commences growth after the manner of *Clavulina angularis*, and not only the triserial segments but the earlier portion of the uniserial line have the angular contour of that species. The remainder of the test is cylindrical, and the segments are even more distinct and individually rounded than in most examples of *Clavulina parisiensis*. The length scarcely exceeds $\frac{1}{30}$th inch (0·8 mm.).

Clavulina angularis, d'Orbigny (Pl. XLVIII. figs. 22–24).

Clavulina angularis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 268, No. 2, pl. xii. fig. 7.
„ *tricarinata*, Id. 1839, Foram. Cuba, p. 114, pl. ii. figs. 16–18.
Vulvulina angularis, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 305, No. 92
Clavulina triquetra, Reuss, 1864, Denkschr. d. k. Akad. Wiss. Wien, vol. xxiii. p. 6, pl. i. fig. 1.

In this species the angular outline is not confined to the triserial portion of the test, as in *Clavulina parisiensis*, but is retained during the growth of the Nodosarian segments, so that the entire shell has the form of a more or less regular three-sided prism. The little fossil figured by Reuss (*loc. cit.*), under the name *Clavulina triquetra*, differs in no respect from the recent specimens.

Clavulina angularis is found in the shore-sands of Cuba and Jamaica (d'Orbigny), and in dredged material from the Mediterranean and the Red Sea. It occurs at one point in the South Atlantic, Station 122, off Pernambuco, 350 fathoms, and at numerous localities amongst the islands of the Eastern Archipelago, in shallow water, from 8 to 28 fathoms.

It may be inferred from Reuss's specimens, which were obtained from the Nummulitic beds of Oberburg in Styria, that the species made its appearance about the same time as its congeners *Clavulina communis* and *Clavulina parisiensis*, that is to say, near the commencement of the Tertiary epoch.

Clavulina angularis, var. *difformis*, nov. (Pl. XLVIII. figs. 25–31).

At one locality, Nares Harbour, Admiralty Islands, nearly under the equator, a large proportion of the *Clavulinæ* pertaining to the species last described, instead of presenting the normal triangular contour, assume a number of irregular and anomalous forms, amongst the commonest of which are the four- and five-angled varieties represented in figs. 25–31. It has been thought better to distinguish these by a subordinate name, inasmuch as such specimens found alone would almost certainly be supposed to belong to an independent species, rather than to a mere local variety.

Clavulina cylindrica, Hantken (Pl. XLVIII. figs. 32-38).

Clavulina cylindrica,[1] Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt., vol. iv. p. 18, pl. i. fig. 8.

The drawings of this species in Pl. XLVIII. suggest, rather than fully illustrate, the diversity in size and contour which the test assumes. Specimens vary in length from $\frac{1}{50}$th to nearly $\frac{1}{5}$th inch (0·5 mm. to 5·0 mm.), and between the long, tapering,

[1] In the Tableau Méthodique, *Ann. Sci. Nat.*, vol. vii. p. 268, No. 1, the name *Clavulina cylindrica* is applied to one of the fossil forms found in the Subapennine Tertiaries; but as it is unaccompanied in that work by either description or figure, there is nothing to prevent its transfer to von Hantken's species.

cylindrical forms, such as fig. 32, and those of subglobular shape, like figs. 34 or 35, every variety is to be found.

Well-developed specimens of *Clavulina cylindrica* closely resemble *Haplostiche soldanii* (Pl. XXXII. figs. 12–18), not only in contour but in shell-texture. These two species often abound in the same localities, especially amongst the coral-sands of the tropics, and very frequently the orifice furnishes the only external characters by which they can be distinguished the one from the other. In the Lituoline test the aperture is either simple or labyrinthic, whilst in perfect specimens of *Clavulina cylindrica* it is always valvular. The longitudinal section of either organism at once reveals its affinity; but the external character referred to is of interest from a morphological point of view, and of value as affording a ready means of diagnosis.

The walls of the test are thick, and in the ovate and rounded forms the septation is entirely concealed by their massive development; but in the more elongate cylindrical varieties, the thickening is less conspicuous, and the septation of the uniserial line of segments is indicated by slight external depressions.

Von Hantken's drawings of the species represent a test of similar contour to fig. 32, but the aperture has no valvular tongue, a feature often wanting in fossil specimens.

Clavulina cylindrica has been collected at four Stations in the North Atlantic,—off Gomera, Canaries, 620 fathoms; off Sombrero Island, West Indies, 450 fathoms; off Bermuda, 435 fathoms, and off the Azores, 450 fathoms: at one in the South Atlantic,—east of Buenos Ayres, 1900 fathoms: and at three in the South Pacific,—west coast of New Zealand, 275 fathoms; off Kandavu, Fiji Islands, 210 fathoms; and off Raine Island, Torres Strait, 155 fathoms.

Von Hantken gives a considerable list of localities for the species in the Lower *Clavulina-szabói* formation of Hungary, and states that it also occurs in the Bryozoa-marl of Priabona in Italy.

Sub-family 2. Bulimininæ.

Bulimina, d'Orbigny.

Bulimina, d'Orbigny [1826], Römer, Reuss, Alth, Bailey, Costa, Bornemann, Parker and Jones, Egger, Williamson, Karrer, Carpenter, Brady, M. Sars, Schwager, Gümbel, Hantken, &c.
Robertina, d'Orbigny [1846], Reuss.
Rotalina, pars, Reuss [1851].
Cucurbitina, pars, Costa [1856].
Ataxophragmium, Reuss [1861], Karrer.
Pulvinulina, pars, Jones and Parker [1872].
Cassidulina, pars, Brady [1881].

In the typical condition, the shell of *Bulimina* takes the form of an elongated spire, of which the final convolution is conspicuously large. The segments are numerous

and more or less inflated, small at the commencement and rapidly increasing in size. The aperture is a loop-like or comma-shaped slit, on the face of the terminal chamber, generally inserted near the distal end, and directed obliquely or vertically downwards.

These characters are liable to modification in many different ways, and even within the limits they embody there is room for considerable diversity of aspect from variation in minor particulars. For example, the spire may have many segments in each convolution, or it may be only triserial; or, as often happens, the chambers may be so irregularly disposed that the spiral arrangement is altogether lost; the convolutions may be so drawn out that the test has the contour of a narrow cylinder, or they may be so nearly on the same plane that it resembles a depressed Rotalian; the chambers are sometimes inflated and globular, as in *Bulimina elegans*, and sometimes long and compactly fitted side by side, as in *Bulimina elegantissima;* and lastly the aperture, though the most characteristic feature of the genus, in certain cases exchanges its normal shape for that of a nearly circular opening with a border of radiating lines.

The shell-wall in recent specimens is invariably calcareous, generally very thin and transparent, and distinctly though finely perforated. The shells of a number of species are ornamented externally, either with raised longitudinal costæ, or with marginal teeth or spines, still preserving their hyaline texture. But amongst the larger fossil forms, especially those of Cretaceous age, the test is liable to become encrusted with calcareous or siliceous sand or other foreign matter, and is consequently often thick and opaque, and somewhat rough externally. Undue importance has been attached to this character by Reuss and others,[1] who have assigned the subarenaceous species to a distinct genus, *Ataxophragmium*,—a course for which there appears no adequate reason, and to which there are many objections.

In one form or other the genus *Bulimina* is distributed over the whole world, and though it attains its best development on sea-bottoms of moderate depth, that is to say at less than 1000 fathoms, it has been met with as low down as 2400 fathoms.

Its geological range commences with the Upper Trias (Parker and Jones); it occurs in the Oolitic, and is abundant in the Cretaceous formation; and is found more or less plentifully at every stage of the Tertiary epoch.

Bulimina elegans, d'Orbigny (Pl. L. figs. 1–4).

Bulimina elegans, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 270, No. 10;—Modèle, No. 9.
„ „ Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 20, pl. ii. fig. 64.

D'Orbigny's model, No. 9, represents a regularly triserial tapering shell, the segments of which are numerous and rather small, distinct and more or less inflated or sometimes almost globular. It serves as a central type of a somewhat numerous group of recent *Buliminæ*.

Bulimina elegans is a not uncommon species in the North Atlantic, at various depths from 11 fathoms to 1630 fathoms; and occurs also off the Cape of Good Hope, off New Zealand, amongst the islands of the South Pacific, and elsewhere. D'Orbigny's specimens were obtained from the Adriatic near Rimini.

Bulimina elegans, var. *exilis*, nov. (Pl. L. figs. 5, 6).

Test much elongated, slender, tapering, more or less compressed on three sides; oral end subacute or rounded, aboral extremity acuminate. Segments numerous, oblique, somewhat inflated, arranged in a regular triserial spire. Length, $\frac{1}{35}$th inch (0·75 mm.).

This is a much attenuated variety of *Bulimina elegans*, exhibiting characters about midway between that species and *Virgulina schreibersiana*. Such forms are by no means rare in deep water (1000 to 1500 fathoms) in the North Atlantic, and have also been met with in both the North and South Pacific (350 to 800 fathoms).

Bulimina pyrula, d'Orbigny (Pl. L. figs. 7–10).

Bulimina caudigera, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 270, No. 16;—Modèle, No. 68.
„ *ovula*, Id. 1839, Foram. Amér. Mérid., p. 51, pl. i. figs. 10, 11.
„ *pyrula*, Id. 1846, For. Foss. Vien., p. 184, pl. xi. figs. 9, 10.
„ *auriculata*, Bailey, 1851, Smithsonian Contrib., vol. ii., Art. 3, p. 12, figs. 25–27.
„ *turgida*, Id. Ibid. p. 12, figs. 28–31.
Guttulina prunella, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 274, pl. xiii. figs. 32, 33, 37, 38.
„ *mutabilis*, Id. Ibid. p. 275, pl. xviii. figs. 1–3.
Bulimina auriculata, Dawson, 1859, Canad. Nat., vol. iv. p. 31, fig. 22.
„ *presli*, var. *pyrula*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 372, pl. xv. figs. 8, 9.

Messrs. Parker and Jones have selected the drawings given by d'Orbigny in the "Vienna Basin" monograph, as the best representation of the typical characters of this species; and as the name by which it is there distinguished, *Bulimina pyrula*, has been generally adopted, it does not appear worth while to disturb the arrangement. Nevertheless, prior to the publication of the memoir referred to, the species had been named at least twice by the same author, first in 1826, as *Bulimina caudigera*, and then in 1839, as *Bulimina ovula*. Oddly enough, the model of *Bulimina caudigera* has no "tail," and only differs from *Bulimina pyrula* in being more distinctly oval; whilst *Bulimina ovula* is apiculate at the base, and might with some reason have been termed "*caudigera*." However this may be, the three names have been employed for slightly different modifications of the same species, and, as the same author is concerned in all, there can be no objection to retaining the term already in common use.

Bulimina pyrula is characterised by its erect, overlapping segments, of which the last three, forming the final convolution, are often all that are visible on the exterior. The

test is ovate or pyriform, and sometimes slightly flattened on three sides. The shell-wall is generally exceedingly thin and transparent.

The species is common to the North and South Atlantic, the North and South Pacific, the Indian Ocean, and the Mediterranean. It is especially abundant in the North Atlantic, and, though it does not reach as far north as some of its congeners, has been found between lat. 65° and 70° N., off the coast of Norway. Its extreme bathymetrical range, so far as has been ascertained, is from 37 to 2550 fathoms, but a very large proportion of the recorded localities are at depths between 100 and 1200 fathoms.

The geological history of *Bulimina pyrula* extends over a considerable period. It is stated by Parker and Jones that "a *Bulimina* of very similar shape occurs in the Upper Triassic Clay of Chellaston." The species is found in the Eocene clay of the London Basin (Parker and Jones); in the Miocene formations of the neighbourhood of Vienna (d'Orbigny); in the Pliocene of Southern Italy (Costa); and in the Post-pliocene deposits of Canada (Dawson).

Bulimina pyrula, var. *spinescens*, nov. (Pl. L. figs. 11, 12).

In general contour the figured specimens closely resemble the drawings given by d'Orbigny of *Bulimina pyrula* (For. Foss. Vien., pl. xi. figs. 9, 10), but the broad initial end of the test is beset with short spines. Parker and Jones, in their notes on *Bulimina pyrula* (Phil. Trans., vol. clv. p. 372), state of the typical form, that "it is usually prickled at the apex." This is probably intended to refer primarily to their Norwegian gatherings, and it does not hold good as a general rule; for, amongst specimens from at least forty or fifty localities, the only examples in the spinous condition are a comparatively small number from a single Station in the Eastern Archipelago, namely,—off Ki Islands, depth, 580 fathoms.

Bulimina ovata, d'Orbigny (Pl. L. fig. 13, *a.b.*).

Bulimina ovata, d'Orbigny, 1846, For. Foss. Vien., p. 185, pl. xi. figs. 13, 14.
„ *pedunculata*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 334, pl. xviii. fig. 13.

Bulimina affinis, d'Orbigny (Pl. L. fig. 14, *a.b.*).

Bulimina affinis, d'Orbigny, 1839, Foram. Cuba, p. 109, pl. ii. figs. 25, 26.
„ *ovulum*, Reuss, 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 38, pl. iv. fig. 9.

Bulimina pupoides, d'Orbigny (Pl. L. fig. 15, *a.b.*).

Bulimina pupoides, d'Orbigny, 1846, For. Foss. Vien., p. 185, pl. xi. figs. 11, 12.
„ „ Williamson, 1858, Rec. For. Gt. Br., p. 62, pl. v. figs. 124, 125.
„ *presli*, var. *pupoides*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
„ *pupoides*, Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 193, pl. ii. figs. 30–34.

The three *quasi*-specific groups above enumerated cannot be separated, except by comparative characters too variable to be of any real zoological value. The most that

can be said to distinguish them is that *Bulimina ovata* is more regularly ovate and generally rather longer proportionately than its allies; that *Bulimina affinis* tapers more evenly towards the aboral extremity; and that *Bulimina pupoides* has usually shorter segments, and their spiral arrangement is more apparent. It may be questioned whether anything is gained by retaining "species" on these terms.

Bulimina ovata is common in littoral sands on our own coast, and is generally distributed over the North Atlantic, at depths of less than 1400 fathoms. It occurs in the South Atlantic as low as 2200 fathoms; and in the South Pacific from 15 to 580 fathoms. It is found as a fossil in the Eocene beds of the Isle of Wight (Brady), in the Miocene of the Vienna Basin (d'Orbigny), in the later Tertiary deposits of Southern Italy (Costa), and in the Post-tertiary clays of Norway and the west of Scotland (Crosskey and Robertson).

Of *Bulimina affinis* the Challenger collections furnish examples from the western coast of Patagonia, 565 fathoms, and from the deep area of the North Pacific, 3125 fathoms. D'Orbigny's single specimen was found in shore-sand from Cuba. There is nothing, to all appearance, in Reuss's figures of *Bulimina ovulum* to separate them morphologically from the present species, and if that be so its geological history goes back as far as the Cretaceous epoch.

Bulimina pupoides occurs upon our own shores, as well as over a wide area of the North Atlantic, ranging from shallow water to a depth of 1000 fathoms. It has also been met with in the Indian Ocean, off the Cape of Good Hope, and at various points amongst the islands of the South Pacific. In the fossil condition it is found in the Miocene of the Vienna Basin (d'Orbigny), in the later Tertiaries of the neighbourhood of Rome (Terrigi), and in the Post-tertiary deposits of Norway, Scotland, Italy, and Canada (Sars, Crosskey and Robertson, Vanden Broeck, Dawson).

Bulimina elongata, d'Orbigny (Pl. LI. figs. 1; and 2 ?).

Bulimina elongata, d'Orbigny, 1846, For. Foss. Vien., p. 187, pl. xi. figs. 19, 20.
„ *eocena*, Hantken, 1872, Jahrb. d. k. ungar. geol. Anstalt, vol. i. p. 136, pl. ii. fig. 16.

This also is a form that might properly be placed in the same series as the foregoing, although in its extreme development the lower portion of the test is even more attenuated than the specimens represented in the drawings, and the whole shell is sometimes more or less curved. In point of contour fig. 1 stands about intermediate between d'Orbigny's *Bulimina elongata* and Reuss's *Bulimina imbricata* (Haidinger's Naturw. Abhandl., vol. iv. p. 38, pl. iv. fig. 7), whilst the stouter specimen (fig. 2) is a connecting link with *Bulimina ovata*.

Elongate varieties like these occur in the North Atlantic, 630 fathoms, and in the South Atlantic, 1425 fathoms. The localities given by d'Orbigny are—living, in the Adriatic (?), and fossil, in the Miocene at Nussdorf near Vienna. Von Hantken's *Buli-*

mina eocena, the drawing of which is almost an exact counterpart of our figures of the present species, is from the Lower Tertiary deposits of Gran in Hungary, and Reuss's *Bulimina imbricata* is from the Chalk-marl of Lemberg.

Bulimina subornata, n. sp. (Pl. LI. fig. 6, *a.b.*).

Test oblong-ovate; resembling that of *Bulimina pupoides* in general form and segmentation; the earlier chambers ornamented externally with raised longitudinal costæ; the aboral extremity generally armed with a stout spine. Shell-wall conspicuously foraminated. Length, $\frac{1}{50}$th inch (0·5 mm.).

Bulimina subornata is a rare species, occurring only at two of the Challenger Stations, both in the Pacific, namely:—the *Hyalonema*-ground, south of Japan, 345 fathoms, where it is tolerably plentiful, and off Aru Island, 800 fathoms.

Bulimina elegantissima, d'Orbigny (Pl. L. figs. 20–22).

Bulimina elegantissima, d'Orbigny, 1839, Foram. Amér. Mérid., p. 51, pl. vii. figs. 13–14.
„ „ Williamson, 1858, Rec. For. Gt. Br., p. 64, pl. v. figs. 134, 135.
„ *presli*, var. *elegantissima*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
„ *pulchra*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 114, pl. xii. figs. 8–12.

The test of *Bulimina elegantissima*, as portrayed by d'Orbigny, is distinctly and regularly spiral. It consists of from two to three convolutions, the last of which occupies more than three-fourths of the visible shell. The chambers number from seven to ten in the final whorl; they are long, in the direction of the axis of the test, narrow, and obliquely set, and the sutures are only slightly excavated. Williamson's figures agree in all important respects with those accompanying the original description, the final convolution being represented of even larger proportionate size. Of the drawings given herewith, figs. 20 and 21 are from specimens exhibiting intermediate characters, not so pointed at the inferior extremity as d'Orbigny's, but less obtuse than those selected by Williamson; whilst fig. 22 is from a slightly irregular and misshapen example.

Parker and Jones (Phil. Trans., vol. clv. p. 374, pl. xv. figs. 12–17) assign to the present species a series of specimens which, though they pertain to the same section of the genus, differ in many ways from the typical *Bulimina elegantissima*. In the specimens referred to the segments are short and broad, as compared with those of the type, the final convolution is seldom of the same preponderating size, and the aperture is inserted much further from the distal end of the test. Shells of this sort are much more common than those of the true d'Orbignian form, and they have since been made the basis of an independent species, *Bulimina subteres*.

Bulimina elegantissima has been observed as far north as the west coast of Novaya Zemlya, and is found on the shores of Great Britain, Belgium, and France. The Challenger gatherings furnish specimens from the Falkland Islands, 6 fathoms, from two points on the east coast of Australia, 2–10 fathoms and 410 fathoms respectively; and from four Stations amongst the islands of the South Pacific, 6 fathoms to 610 fathoms. The species is stated by d'Orbigny to be frequent on the western coast of South America, all the way from Peru to Cape Horn.

It is found as a fossil in the Barton Beds of the Eocene series of the Isle of Wight (Brady), in the Eocene deposits of the environs of Paris (Terquem), and in the Post-tertiary clays of Norway (Crosskey and Robertson).

Bulimina elegantissima, var. *seminuda*, Terquem (Pl. L. figs. 23, 24).

Bulimina seminuda, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 117, pl. xii. fig. 21.

This variety presents similar general features to *Bulimina elegantissima*, and exhibits the same regularly spiral mode of growth; but it differs from the typical form in its stouter build and in the greater obliquity of the segments. The shell-wall is usually thick, and the exterior is often partially striate or costate near the initial end. The morphological characters of many specimens approach very closely to those of *Bulimina presli*, one of the most important of the Cretaceous species.

The best living examples of *Bulimina elegantissima*, var. *seminuda*, have been met with as follows:—off East Moncœur Island, Bass Strait, 38 fathoms; south of the Canaries, 1525 fathoms; off Calpentyn, Ceylon, 2 fathoms; and in shore-sands from Madagascar. Intermediate specimens, connecting the variety with the type, occur at two points on the east coast of South America, 675 fathoms and 350 fathoms respectively; and off St. Vincent, Cape de Verde Islands, 11 fathoms.

Terquem's fossil specimens were from the Eocene beds of the neighbourhood of Paris.

Bulimina subteres, H. B. Brady (Pl. L. figs. 17, 18).

Bulimina presli, var. *elegantissima*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 374, pl. xv. figs. 12–17.
„ *elegantissima* (var.), Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 436, pl. xxi. fig. 12.
„ *subteres*, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 55.
„ „ Wright, 1882, Proc. Belfast Nat. Field Club, 1880–1881, App. p. 180, pl. viii. figs. 2, 2*a*.

Test elongate-ovate, tapering to a blunt point at the initial extremity, rounded at the distal end; consisting of from two to three, more or less regular, oblique convolutions.

Chambers relatively large and only slightly ventricose externally; sutural lines very distinct. Aperture a curved slit near the inferior umbilical margin of the terminal chamber, considerably removed from the distal end of the test. Length, $\frac{1}{60}$th to $\frac{1}{40}$th inch (0·4 to 0·6 mm.).

This form belongs to the same section of the genus as *Bulimina elegantissima*, and its characters have already been noticed in connection with that species. It is also closely related to the *Bulimina* (*Robertina*) *arctica* of d'Orbigny (For. Foss. Vien., p. 203, pl. xxi. figs. 37, 38).

Bulimina subteres has a wide geographical distribution. It was one of the Foraminifera collected at the most northerly point attained on the last British North-Polar Expedition, lat. 83° 19′ N., and it has been found in Davis's Strait, and on the coast of Novaya Zemlya. It inhabits the Faröe Channel, the west coast of Scotland, and the north and west coast of Ireland. It appears at five Challenger Stations in the North Atlantic, 390 to 1125 fathoms; at two in the South Atlantic, 420 fathoms and 625 fathoms, and at eight in the South Pacific, 28 to 610 fathoms.

Bulimina subcylindrica, H. B. Brady (Pl. L. fig. 16, *a.b.*).

Bulimina subcylindrica, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 56.

Test elongate, oval or subcylindrical, the two ends equally rounded; visible segments few in number, slightly inflated; spiral arrangement very obscure; sutures distinct. Aperture a narrow, curved, nearly erect slit, on the face of the terminal chamber, near its inferior umbilical margin. Length, $\frac{1}{60}$th inch (0·4 mm.).

This species belongs to the same section of the genus as *Bulimina subteres*, and differs from the latter chiefly in its regularly oval contour, its comparatively few segments, and their less oblique setting.

Bulimina subcylindrica occurs at two Stations in the North Atlantic,—off Gomera, Canaries, 620 fathoms, and off Cape de Verde Islands, 1070 fathoms; at one in the South Atlantic,—off Pernambuco, 675 fathoms; and at three in the South Pacific,—Torres Strait, 155 fathoms, off Tahiti, 620 fathoms, and off the west coast of Patagonia, 175 fathoms.

Bulimina declivis, Reuss (Pl. L. fig. 19, *a.b.*).

Bulimina declivis, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 55, pl. vi. fig. 70; pl. vii. fig. 71.
„ *imperatrix*, Karrer, 1868, Ibid. vol. lviii. p. 176, pl. iv. fig. 11.
„ *declivis*, Reuss, 1870, Ibid. vol. lxii. p. 484, No. 2;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxiii. figs. 8–12.

Bulimina declivis also belongs to the same group as *Bulimina subteres*. In typical specimens the test is broad and tapers rapidly to a point; the chambers are numerous,

and form fully three convolutions. They are very convex externally, and the sutural lines are much depressed. One of Reuss's original figures (*loc. cit.*, pl. vii. fig. 71) agrees in all important points with the recent specimens; the other (pl. vi. fig. 70) is scarcely so broad, and the segments are less inflated. Von Schlicht's drawings, subsequently referred by Reuss to the same species, represent irregular shells of similar general conformation, some of which have subglobular chambers. Dr. Karrer's figure of *Bulimina imperatrix* exhibits slightly greater proportionate length, but does not appear to differ otherwise from those above mentioned.

The Challenger collections have yielded specimens of *Bulimina declivis* from only one locality:—off the Ki Islands, 580 fathoms.

In the fossil condition it has been obtained from the Septaria-clays of Offenbach and Pietzpuhl in North Germany (Reuss), and from the Miocene deposits of Kostej in the Banat (Karrer).

Bulimina marginata, d'Orbigny (Pl. LI. figs. 3–5).

Bulimina marginata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 269, No. 4, pl. xii. figs. 10–12.

„ *pulchella*, d'Orbigny, 1839, Foram. Amér. Mérid., p. 50, pl. i. figs. 6, 7.

„ *acanthia*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 335, pl. xiii. figs. 35, 36.

„ *elegans*, Id. Ibid. p. 334.

Cucurbitina cruciata, Id. Ibid. p. 366, pl. xviii. fig. 7.

Bulimina pupoides, var. *marginata*, Williamson, 1858, Rec. For. Gt. Br., p. 62, pl. v. figs. 126, 127.

„ *presli*, var. *marginata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 372, pl. xv. fig. 10, pl. xvii. fig. 70.

„ *marginata*, Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 194, pl. ii. figs. 35, 36.

Bulimina marginata is a common and easily recognised species. The test is either ovate or tapering, and each chamber is somewhat extended backwards externally, so as to form a free edge, which is conspicuously serrate or crenulate.

I find no certain record of the occurrence of this species further north than the Faröe Channel; but it is a common constituent of the littoral fauna of the Atlantic shores of Europe, and is by no means confined to shallow water, but extends in mid-ocean to a depth of 1630 fathoms. It is equally abundant in the South Pacific; but in the South Atlantic and North Pacific it appears to be less frequent. It occurs also in the Southern Ocean, in the Mediterranean, and in the Adriatic.

It has been found as a fossil in the later Tertiaries of Italy (Costa, Terrigi), and in the Post-tertiary beds of Norway (Sars, Crosskey and Robertson), of the west of Scotland (Robertson), and of the north of Ireland (Wright).

Bulimina aculeata, d'Orbigny (Pl. LI. figs. 7–9).

"Polymorpha *Pineiformia*," Soldani, 1791, Testaceographia, vol. i., pt. 2, p. 118, pl. cxxvii. fig. *I*; pl. cxxx. fig. *vv*.
Bulimina aculeata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 269, No. 7.
„ *patagonica*, Id. 1839, Foram. Amér. Mérid., p. 50, pl. i. figs. 8, 9.
„ *pupoides*, var. *spinulosa*, Williamson, 1858, Rec. For. Gt. Br., p. 62, pl. v. fig. 128.
„ *presli*, var. *aculeata*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
„ *aculeata*, Siddall, 1879, Catal. Brit. Rec. For., p. 8.

The more or less spinous condition of the test furnishes the characteristic feature of this species. The spines vary in length in different specimens, and they generally spring from the extended inferior edges of the chambers, like the marginal teeth of *Bulimina marginata;* but sometimes they are distributed irregularly over the whole of the earlier portion of the shell. The later chambers are often globose and smooth; if aculeate, the spines are comparatively short and inconspicuous.

Bulimina aculeata follows the same general lines of distribution as *Bulimina marginata;* that is to say, it is abundant in the North Atlantic and the South Pacific, and much less common in the South Atlantic and North Pacific. It covers, however, an even wider geographical area, for it has been found as far north as between Drontheim and the North Cape on the coast of Norway, and as far south as the Antarctic Ice-barrier. A comparison of the distribution-lists shows that on the whole *Bulimina aculeata* affects deeper water than *Bulimina marginata.* Out of twenty-two Challenger Stations at which it has been collected, nine have a depth of more than 1000 fathoms, the deepest being 2740 fathoms.

The species appears in Crosskey and Robertson's list of the fossils of the Glacial Clays of Norway.

Bulimina inflata, Seguenza (Pl. LI. figs. 10–13).

Bulimina inflata, Seguenza, 1862, Atti dell' Accad. Gioenia, vol. xviii., ser. 2, p. 107, pl. i. fig. 10.
„ „ Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 246, pl. vii. fig. 91.
„ *buchiana*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 484, No. 3;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxii. figs. 30–33.

Bulimina inflata is a transition form connecting the spinous *Bulimina aculeata* with the costate *Bulimina buchiana.* The test is either oval or tapering; the chambers are extended backwards as in *Bulimina marginata,* and they are crenulated for some distance within the free edges, so as to form short longitudinal costæ, which are continued beyond the margin as stout projecting spines.

The distribution of *Bulimina inflata* is very similar to that of *Bulimina buchiana,* though the two forms seldom occur at precisely the same localities. It is not quite so

common as the latter species in the North Atlantic, having been noticed at only eight Stations; but it is even more generally diffused in the South Pacific. It has been found at Station 122 in the South Atlantic, and at Station 209 in the North Pacific. The bathymetrical range has a somewhat deeper average than that of *Bulimina buchiana*, the extremes being 95 fathoms and 2435 fathoms; but out of twenty-one localities, only two have a depth of less than 340 fathoms, whilst eight are above 1000 fathoms.

In the fossil condition it occurs in the Septaria-clays of North Germany (Reuss, Schlicht), and in the later Tertiaries of Southern Italy (Seguenza), and of the Nicobar Islands (Schwager).

Bulimina buchiana, d'Orbigny (Pl. LI. figs. 18, 19).

Bulimina buchiana, d'Orbigny, 1846, For. Foss. Vien., p. 186, pl xi. figs. 15–18.
„ *presli*, var. *buchiana*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 374, pl. xvii. fig. 71.
„ *truncana*, Gümbel, 1868, Abh. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 644, pl. ii. fig. 77, *a.b.*
„ *buchiana*, Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 195, pl. ii. fig. 37.

D'Orbigny's figures of *Bulimina buchiana* represent a regularly triserial, tapering shell, with distinct and somewhat inflated segments, and a surface-ornament of continuous longitudinal costæ which extend from the pointed extremity to near the middle of the final whorl of segments. The drawings (Pl. LI. figs. 18, 19) are from specimens a little stouter than d'Orbigny's, but otherwise typical examples of the species.

Bulimina buchiana is intimately connected with *Bulimina inflata* on the one hand, and *Bulimina rostrata* on the other; and though it might be impossible to separate the three forms by any invariable characters, they are sufficiently distinct under ordinary circumstances to admit of easy identification. The test of *Bulimina inflata* is of similar size to that of the present species, and exhibits the same general structure; but the costæ are short, and are continued beyond the margin of the chambers in the form of stout spines. The test of *Bulimina rostrata* is usually of much smaller dimensions, the costæ are continuous and cover the whole test except a little patch at the distal end, and the segmentation is indistinct or entirely concealed.

Bulimina buchiana affects tolerably deep water. It is abundant in the North Atlantic, from about lat. 60° N. to the equator, at depths of 150 to 1675 fathoms, and has been found in one locality at 90 fathoms. It is scarce in the South Atlantic, having only been noticed at two Stations near Pernambuco, depth 350 fathoms and 675 fathoms respectively; it is moderately common in the South Pacific, 129 fathoms to 2375; and has been obtained off the Cape of Good Hope, 150 fathoms. The species has not been observed in any part of the North Pacific.

As a fossil it has been found in the Nummulitic beds of the Bavarian Alps (Gümbel), in the Miocene of the Vienna Basin (d'Orbigny), and in the Upper Pliocene Sands of the neighbourhood of Rome (Terrigi).

Bulimina rostrata, n. sp. (Pl. LI. figs. 14, 15).

Bulimina truncana, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 61, pl. vii. fig. 5.

Test elongate fusiform, broadest near the middle, tapering unequally towards the two ends; oral end obtuse or rounded, aboral portion of the shell drawn out to a fine point and often obliquely bent. Segmentation almost or entirely concealed by the surface-ornament, which consists of stout, continuous, longitudinal costæ, covering the test except a small area at the distal end. Aperture of the normal Bulimine character. Length, $\frac{1}{80}$th inch (0·3 mm.) or more.

From von Hantken's figure (*loc. cit.*), this appears to be the variety assigned by him to *Bulimina truncana*, Gümbel, with the remark that the specimens belong to the *Bulimina buchiana* group, but are of slighter build than Gümbel's Bavarian form.

Bulimina rostrata has been identified at four Challenger Stations, all of them in tolerably deep water:—off Cape de Verde Islands, 1070 fathoms; north of Tristan d'Acunha, 1425 fathoms; between the Cape of Good Hope and Kerguelen Island, 1570 fathoms; and off the Ki Islands, 580 fathoms. In every case it appears to replace the larger species, *Bulimina buchiana*.

Von Hantken states that the form is common throughout the lower *Clavulina-szabói* beds of Hungary.

Bulimina williamsoniana, H. B. Brady (Pl. LI. figs. 16, 17).

Bulimina williamsoniana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 56.

Test spiral; elongate, cylindrical, slightly tapering, more or less twisted in contour, circular in transverse section; oral end obliquely truncate, aboral extremity rounded. Surface traversed from end to end by a series of somewhat sinuate and diagonal parallel costæ, which entirely conceal the internal structure. Segments numerous, long and narrow, obliquely set; sutures not visible or only very slightly marked on the exterior. Aperture simple, rounded; situate in a depression at the centre of the obliquely truncate distal end, bordered by radiating lines. Length, $\frac{1}{40}$th inch (0·64 mm.) or less.

This beautiful little species, which I have had pleasure in naming after our veteran Rhizopodist, Prof. W. C. Williamson, appears to be limited in its distribution to the South

Pacific. Its occurrence has been noted at seven localities, namely:—Port Stephens and Port Jackson, New South Wales, 2 to 10 fathoms; off Levuka, Fiji, 12 fathoms; off the New Hebrides, 125 fathoms; Torres Strait, 155 fathoms; Humboldt Bay, Papua, 37 fathoms; and Nares Harbour, Admiralty Islands, 17 fathoms.

Bulimina contraria, Reuss, sp. (Pl. LIV. fig. 18, *a.b.c.*).

Rotalina contraria, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesell., vol. iii. p. 76 pl. v. fig. 37.
Ataxophragmium simile, Karrer, 1863, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lvii. p. 126, pl. i. fig. 1.
Pulvinulina auricula, Jones and Parker, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 126.
Cassidulina jonesiana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 59.

The somewhat anomalous characters of *Bulimina contaria*, and its striking resemblance to certain *Rotalinæ*, have been the cause of the confusion revealed by the above synonymy of the species. The general contour of the test and the arrangement of the segments are precisely those of a depressed Rotalian, and at first sight it may easily be mistaken for *Pulvinulina auricula* or one of its immediate allies; nevertheless the aperture is always characteristic and distinctly Bulimine. Guided by the stout, subdiscoidal or rounded contour of the shell, and the loop-like orifice, I was myself led into an error of another sort, and in a former paper (*loc. cit.*), placed the species amongst the *Cassidulinæ*, overlooking the fact that there was no real alternation of segments. The salient difference between *Bulimina contraria* and the more typical members of the group depends upon the fact that the increase of the spire takes place in a lateral rather than in a vertical direction. *Ataxophragmium simile*, to judge by Dr. Karrer's drawings, differs from the recent examples of the present species in little else than its somewhat more distinct and inflated segments.

Bulimina contraria has been obtained at nine Challenger Stations. Of these, one is in the North Atlantic, off Cape de Verde Islands, 1070 fathoms; one in the North Pacific, the *Hyalonema*-ground, south of Japan, 345 fathoms; and the remaining seven are in the neighbourhood of the islands of the South Pacific, the depths ranging from 17 fathoms to 1350 fathoms.

The fossil specimens described by Reuss were from the Septaria-clay (Oligocene) of Hermsdorf, near Berlin; and those of Karrer's memoir from the Miocene of Kostej in the Banat.

Bulimina convoluta, Williamson (Pl. CXIII. fig. 6, *a.b.*).

Bulimina pupoides, var. *convoluta*, Williamson, 1858, Rec. For. Gt. Br., p. 63, pl. v. figs. 132, 133.

A somewhat obscure Rotaliform species, bearing a certain resemblance to that last described, but of longer oval outline and with a greater amount of lateral compression.

Just at its commencement the test is planospiral; but with this exception, it is formed of two oblique nearly parallel series of segments, exactly as described by Prof. Williamson. Unfortunately the original drawings of this species (*loc. cit.*), do not show the segmentation of the test at all clearly, probably because the specimens themselves were wanting in definition, and guided by them Dr. Carpenter has been led to the conclusion that "the later segments present a uniserial rectilinear succession" (Introd. Foram., p. 195), which is certainly not the case in the examples that have come under my notice. It appears to me open to doubt whether the form has not more in common with the partially uncoiled *Cassidulinæ* than with the present genus;—the few specimens which I have examined suggest rather than decide the question.

Bulimina convoluta is a very rare Foraminifer. The Challenger specimens are from a single Station,—the rich sounding off Raine Island, Torres Strait, depth 155 fathoms; Williamson's were from Shetland and Skye; and the Rev. A. M. Norman has good examples from two points on the coast of Norway, namely,—off Stoksund, 126 fathoms, and off Sartoröe, near Bergen, 40 fathoms. These five localities embrace all that is known of its distribution.

Pleurostomella, Reuss.

Pleurostomella, Reuss [1860], Schwager, Gümbel, Hantken, Wright, Marsson, Moore, Berthelin, Brady, Terrigi.

The genus *Pleurostomella* was established by Reuss for two subcylindrical forms of Foraminifera found in the Cretaceous beds of Westphalia.[1] These, which though separately named probably belong to the same species, resemble irregularly built Nodosarians, the one curved or Dentaline, the other straight. The chambers are numerous and joined end to end, but their sutures are oblique and in a certain sense alternating, that is to say, inclined first towards one side and then towards the other. The segments are disposed in single series, and except just at the commencement of one of the specimens, there is no approach to true Textularian arrangement. Guided by the contour of the individual segments and the apparent plan of growth, the genus was originally placed by Reuss in a family by itself, at the end of d'Orbigny's Order Stichostegia, immediately following *Vaginulina*; and in his own subsequent classification of the Foraminifera, the *Pleurostomellidea* were assigned to the Rhabdoidea.[2] In either case the type was treated as one having close affinity to the *Nodosarinæ*.

But in many ways the Cretaceous specimens on which the genus was founded do not fully represent its characteristic features. These were first brought into notice by the beautiful drawings accompanying Dr. Schwager's memoir on the fossil Foraminifera of

[1] *Sitzungsb. d. k. Ak. Wiss. Wien*, vol. xl. p. 59, pl. viii. figs. 1, 2.

[2] *Ibid.*, vol. xliv. pp. 368, 395.

Kar Nicobar ;[1] and the same author in his recent scheme of classification has remitted the type to what is evidently its natural position, placing it in the same group with *Bulimina* and *Virgulina*.[2]

In its fully developed condition the test of *Pleurostomella* is biserial and Textularian ; in the exceptional cases in which it is uniserial, the later segments are obliquely set and alternating. The septal face is oblique or nearly vertical, and is directed alternately towards the two peripheral edges of the test. The aperture is situated on the septal face of the terminal segment, close to the distal extremity, usually in a slight depression. It is subject to a good deal of variation in point of form, but in typical specimens consists of a dome-shaped or semicircular orifice, with a vertical notch or slit at the middle of the inferior edge. In some shells the notch is wanting, in others the aperture has the appearance of a T-shaped fissure, whilst in others again, it takes the shape of a symmetrical three- or four-lobed opening.

The geographical distribution of *Pleurostomella* as a recent genus, so far as at present known, is limited to one or two localities in the South Pacific and South Atlantic. As a fossil it has been found in various portions of the Cretaceous system of Bohemia and North Germany (Reuss, Marsson), England (Moore), Ireland (Wright), and France (Berthelin); in the earlier Tertiary formations of South Germany (Gümbel), and Hungary (Hantken) ; and in the later Tertiary deposits of the Nicobar Islands (Schwager), and Central Italy (Terrigi).

Pleurostomella brevis, Schwager (Pl. LI. fig. 20, *a.b.*).

Pleurostomella brevis, Schwager, 1866, Novara-Exped., geol. Theil, vol ii. p. 239, pl. vi. fig. 81.

The original figures of this species represent a somewhat compressed, ovate test, with comparatively few segments and rounded base. The specimen portrayed in Pl. LI. fig. 20, *a.b.*, is of similar contour, but has even fewer segments.

This variety occurs with other *Pleurostomellæ* off the Ki Islands, Indian Archipelago, 129 fathoms.

Dr. Schwager's fossil specimens were from the rich Pliocene deposits of the Nicobar Islands.

Pleurostomella rapa, Gümbel (Pl. LI. fig. 21, *a.b.*).

Pleurostomella rapa, Gümbel, 1868, Abh. d. k. bayer. Ak. Wiss., II. Cl., vol. x. p. 630, pl. i. fig. 54.

The figured specimen answers pretty closely to Gümbel's description of this species ; but unfortunately his drawing (*loc. cit.*) only gives one aspect of the shell, and is on too small a scale to be of much assistance as to minute characters. The test is short, very broad at the distal end, and tapers rapidly to a point at the initial extremity; the

[1] Novara-Exped., geol. Theil, vol. ii. pl. vi. figs. 79–81.

[2] *Bollet. del R. Com. Geol.*, 1876–1877.

segments of the final pair are relatively large, and constitute the principal part of the whole visible shell.

Pleurostomella rapa has been found in company with the species last described, in coral-sand dredged off the Ki Islands, at a depth of 129 fathoms.

Prof. Gümbel's fossil specimens were from the Eocene marl of the Götzreuther Graben in the Bavarian Alps.

Pleurostomella alternans, Schwager (Pl. LI. figs. 22, 23).

Pleurostomella alternans, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 238, pl. vi. figs. 79, 80.
„ *eocæna*, Gümbel, 1868, Abh. d. k. bayer. Ak. Wiss., II. Cl., vol. x. p. 630, pl. i. fig. 53.
„ „ Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 44, pl. xiii. fig. 17.
„ *alternans*, Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 199, pl. ii. fig. 46.
„ *obtusa*, Berthelin, 1880, Mém. Soc. géol. France, sér. 3, vol. i., Mém. V., p. 29, pl. i. fig. 9.
„ *reussi*, Id. Ibid. p. 28, pl. i. figs. 10–12.

The specimens figured by Dr. Schwager under the name *Pleurostomella alternans* exhibit in their fullest development the typical features of the genus. I find no character in the *Pleurostomella eocæna* of Gümbel not provided for by this species; and if the latitude as to minor particulars indicated by the original drawings be admitted, two of the specific names introduced by M. Berthelin are also needless. It is quite evident, from the variability of the recent specimens of *Pleurostomella alternans*, that an even wider morphological range than that suggested by Dr. Schwager may safely be included within its specific limits.

In the living condition, *Pleurostomella alternans* has been obtained from near the Ki Islands, south-west of Papua, 129 fathoms; and from a single Station south of the Low Archipelago, 2075 fathoms.

Under one name or other, the occurrence of fossil specimens has been recorded from the Cretaceous formation of France (Berthelin), from the early Tertiaries of the Bavarian Alps (Gümbel), from the middle Tertiaries of Hungary (Hantken), and from the later Tertiaries of the neighbourhood of Rome (Terrigi), and of the Nicobar Islands (Schwager).

Pleurostomella subnodosa, Reuss (Pl. LII. figs. 12, 13).

Nodosaria nodosa (pars), Reuss, 1845, Verstein. Böhm. Kreid., pt. 1, p. 28, pl. xiii. fig. 22 (*fide* Reuss).
Dentalina subnodosa (pars), Id. 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 24, pl. i. fig. 9 (*fide* Reuss).
Pleurostomella subnodosa, Id. 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xl. p. 204, pl. viii. fig. 2, *a.b.*
„ „ Marsson, 1878, Mittheil. Naturw. Vereine Neu-Vorpom. u. Rügen, Jahrg. x. p. 133.

It is exceedingly difficult to separate such forms as those portrayed in figs. 12 and 13 from the attenuated varieties of *Virgulina;* but the apertures appear to indicate more direct affinity with the genus *Pleurostomella;* and in the shape and disposition of the segments the specimens agree with the *Pleurostomella subnodosa* of Reuss.

This particular modification of the type has been met with at two Stations in the South Atlantic, in mid-ocean, 2200 fathoms and 2350 fathoms; and at two in the South Pacific, west of Chili, 1825 fathoms and 1375 fathoms respectively.

As a fossil *Pleurostomella subnodosa* occurs in Cretaceous deposits of various age, in North Germany and Bohemia (Reuss, Marsson).

Virgulina, d'Orbigny.

Virgulina, d'Orbigny [1826], Römer, Bronn, Reuss, Czjzek, Egger, Parker and Jones, Karrer, Brady, M. Sars, Hantken, Schulze, Robertson, &c.
Bulimina, pars, Bailey [1851], Parker and Jones, Williamson.
Polymorphina, pars, Costa [1856].

Excepting the genus *Lagena*, there is no group of hyaline Foraminifera the knowledge of the varietal modifications of which has received larger accessions from the study of the Challenger material than that comprising the aberrant forms of *Bulimina*, included under the generic or subgeneric terms *Virgulina* and *Bolivina*.

In both of these genera the divergence from the typical Bulimine structure is the result of a tendency to assume a simpler mode of growth,—to become, in fact, more or less biserial in the arrangement of their segments, whilst still retaining the characteristic Bulimine aperture. It is impossible to separate the two groups from each other, or indeed from the typical *Buliminæ*, by any well-defined or constant peculiarity; all that can be said by way of distinction is that *Virgulina* is more Bulimine and less Textularian in the disposition of its segments than *Bolivina*, and that *Bolivina*, on the other hand, is more Textularian and less Bulimine.

This distinction may generally be recognised amongst the biserial varieties of *Virgulina* in the inequilateral setting-on of the chambers, and the consequent difference in the appearance of the two lateral faces of the test, whilst in *Bolivina* the two sides are nearly alike. The structural features of the test render it comparatively easy to associate *Virgulina* with its type; but *Bolivina* often only betrays its affinity by the aperture, which takes some form within the range of variation to be found in *Bulimina* itself. Amongst the varieties of *Virgulina* are to be found all the links connecting *Bolivina* with the typical *Bulimina*.

The geographical distribution of the genus *Virgulina* is world-wide, and does not appear to be influenced by latitude or depth of water. Its geological history scarcely extends to the commencement of the Tertiary epoch, but in the Miocene and subsequent formations the genus is of common occurrence.

Virgulina schreibersiana, Czjzek (Pl. LII. figs. 1–3).

Virgulina schreibersiana, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 147, pl. xiii. figs. 18–21.
Polymorphina longissima, Costa, 1856, Atti dell' Accad. Pont., vol. vii. pl. xiii. figs. 22, 23.
„ *appula*, Id. Ibid. p. 286, pl. xviii. fig. 17.
Bulimina marginata ("attenuated variety"), Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 296, pl. xi. fig. 35.
„ *pupoides*, var. *compressa*, Williamson, 1858, Rec. For. Gt. Br., p. 63, pl. v fig. 131.
Virgulina schreibersii, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
Bulimina presli, var. (*Virgulina*) *schreibersii*, Id. 1865, Phil. Trans., vol. clv. p. 375, pl. xv. fig. 18;—pl. xvii. figs. 72, 73.

This species is the commonest of all the Virguline group, and that which presents the nearest approach to the typical Bulimine structure. The test is proportionately longer than in most of the true *Buliminæ*, the segments are fewer, and they exhibit a tendency, especially in the later stages, to a binary or Textularian, rather than a more complex mode of growth.

Virgulina schreibersiana is found in nearly every part of the world. It is abundant in the North Atlantic, and is scarcely less frequent in the South Atlantic, the North and South Pacific, the Indian Ocean, the Red Sea, and the Mediterranean. It is also at home on the shores of Franz-Josef Land and in Smith Sound, as far as 79° or 80° north latitude. Its distribution depends but little on the depth of the sea-bottom, but includes a range of from 10 to 3000 fathoms.

As a fossil it is probably not found earlier than the middle of the Tertiary epoch; but from the Miocene period to the present time it is of constant occurrence in marine formations.

Virgulina pauciloculata, n. sp. (Pl. LII. figs. 4, 5).

Test elongate-oval or subcylindrical, somewhat compressed, tapering slightly; ends rounded; aboral extremity mucronate. Segments few in number, long, erect, but little inflated, irregularly arranged. Aperture a curved loop, situated on the inner face of the final chamber. Length, $\frac{1}{60}$th inch (0·42 mm.).

This is a minute species, sufficiently distinguished by its few, erect segments, and their irregular disposition.

It has been found in four localities, all of them on the shores of Papua or the adjacent islands, namely:—Humboldt Bay, north coast of Papua, 37 fathoms; at Station 189, on the south coast of the same island, 28 fathoms; Torres Strait, 3 to 11 fathoms; and off the Ki Islands, 129 fathoms.

Virgulina squamosa, d'Orbigny.

Virgulina squamosa, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 267, No. 1 ;—Modèle, No. 64.
Bulimina compressa, Bailey, 1851, Smithsonian Contrib., vol. ii. Art. 3, pl. xii. figs. 35–37.
„ *presli*, var. (*Virgulina*) *squamosa*, Parker and Jones, 1865, Phil. Trans., vol. clv p. 375, pl. xv. figs. 19, 20.
Virgulina squamosa, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol xvi. p. 29, pl. ii. fig. 66.

Virgulina subsquamosa, Egger (Pl. LII. figs. 7–11).

Virgulina subsquamosa, Egger, 1857, Neues Jahrb. für Min., &c., p. 295, pl. xii. figs. 19–21.
„ *tenuis*, Seguenza, 1862, Atti dell' Accad. Gioenia, vol. xviii., ser. 2, p. 110, pl. ii. figs. 2, 2*a*.

The successive modifications of the genus *Virgulina* form so complete a gradational series, that it is impossible to mark off by definite lines the groups to which specific names have been given.

To *Virgulina squamosa*, d'Orbigny, have been assigned the comparatively thin varieties that are more distinctly biserial than *Virgulina schreibersiana*. Such forms often resemble the closely allied *Bolivina punctata*, but (accepting d'Orbigny's Model No. 64 as the type) they have fewer segments ; the segments are also more obliquely set, and they are exposed unequally on the two lateral faces of the test.

The *Virgulina subsquamosa* of Egger is nearly related to the foregoing, but is distinguished by its more robust contour and rounded margin, its more numerous segments, and their very oblique inequilateral setting.

So far as these two forms can be separated, the specimens which are represented in figs. 7–11, all belong to *Virgulina subsquamosa* rather than *Virgulina squamosa*.

Virgulina squamosa is not uncommon in the North Atlantic, extending as far north as Baffin's Bay. It is found also in the South Atlantic, in the North and South Pacific, and, according to Parker and Jones, in the Mediterranean and the Red Sea. In many localities it is associated with and inseparable from *Virgulina subsquamosa*, the finest specimens of which occur amongst the islands of the Pacific,—notably off Tahiti, off the Ki Islands, and off the south coast of Japan. The former variety is indifferent to depth, and has a bathymetrical range of from 30 to 3000 fathoms ; the most characteristic specimens of the latter have been taken at depths of from 345 to 620 fathoms.

In the fossil condition these forms make their appearance in the Miocene period, and are met with in various later formations, down to the sub-recent Fen-clays of the east of England.

Virgulina texturata, n. sp. (Pl. LII. fig. 6, *a.b.*).

Test elongate, somewhat compressed, broadest near the oral end and tapering to a point at the aboral extremity ; oral end obtuse or rounded ; margin lobulated. Segments

numerous, ventricose, arranged in two, inequilateral, regularly alternating series. Aperture a nearly erect loop-like slit on the inner face of the final segment. Length, $\frac{1}{20}$th inch (1·3 mm.).

This variety, which attains somewhat larger dimensions than most of its congeners, occurs in company with other *Buliminin*æ at two localities in the South Pacific, not far from the Island of Juan Fernandez, depth 1375 fathoms and 1825 fathoms respectively; and at one point in the Indian Archipelago, off the Ki Islands, 129 fathoms.

Virgulina subdepressa, n. sp. (Pl. LII. figs. 14–17).

Test elongate, subcylindrical, more or less compressed; oral end obtuse, rounded or subangular; aboral extremity broad and rounded; margin crenulate. Segments numerous, triangular in lateral aspect, slightly inflated; arranged in two inequilateral alternating series. Aperture an oblique or nearly erect loop-like slit, on the inner face of the final chamber. Length, $\frac{1}{25}$th inch (1 mm.).

Under this specific name have been grouped a series of intermediate specimens, which it has been found difficult to provide for in any other way. They have, as a rule, stout subcylindrical tests, the morphological characters of which bear an almost equal relation to those of *Virgulina*, *Bolivina*, and *Pleurostomella*. They differ, however, from *Bolivina* in the somewhat inequilateral arrangement of the segments, and from *Pleurostomella* in the form of the aperture; and on the whole, find their nearest allies in the narrow and less tapering varieties of *Virgulina squamosa*.

The specimens referred to were obtained chiefly from one Station in the South Pacific, south-west of Juan Fernandez, 1825 fathoms; and from two in the South Atlantic, mid-ocean, 2200 fathoms and 2350 fathoms respectively.

Bolivina, d'Orbigny.

Bolivina, d'Orbigny [1839], Reuss, Egger, Parker and Jones, Karrer, Carpenter, Brady, Schwager, Hantken, Robertson, Vanden Broeck, Wright, &c.
Vulvulina, pars, d'Orbigny [1839], Carpenter, Seguenza.
Virgulina, pars, Reuss [1845], Wright.
Grammostomum, pars, Ehrenberg [1854].
Brizalina, Costa [1856].

As already stated in the notice of the genus *Virgulina*, the allied type *Bolivina* includes the more distinctly biserial modifications of *Bulimina*. Such forms closely resemble the true Textularians, both as to the general contour of the test and the arrangement of the chambers; and their Bulimine affinity is often only recognised by the elongate unsymmetrical aperture and its oblique or sub-erect insertion.

Geographically speaking, the *Bolivinæ* are very evenly distributed, without much reference to latitude. In one form or other the genus has been found at almost every depth down to 2000 fathoms, but shows a manifest preference for bottoms of less than 300 or 400 fathoms. Its earliest occurrence in the fossil condition is in the Cretaceous period, and from that time forward it is a common constituent of marine microzoic deposits.

Bolivina punctata, d'Orbigny (Pl. LII. figs. 18, 19).

Bolivina punctata, d'Orbigny, 1839, Foram. Amér. Mérid., p. 61, pl. viii. figs. 10–12.
„ *antiqua*, Id. 1846, For. Foss. Vien., p. 240, pl. xiv. figs. 11–13.
Grammostomum polystigma, Ehrenberg, 1854, Mikrogeologie, pl. xix. fig. 84.
„ *caloglossa*, Id. Ibid., pl. xxv. figs. 17, 18.
Bolivina punctata, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 468, pl. xlviii. fig. 9, *a.b.*
Bulimina presli, var. (*Bolivina*) *punctata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 376, pl. xvii. fig. 74.
Bolivina elongata, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 65, pl. vii. fig. 14.
„ *antiqua*, Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 196, pl. ii. fig. 40.
„ *punctata*, Möbius, 1880, Foram. von Mauritius, p. 94, pl. ix. figs. 9, 10.

The characters of *Bolivina punctata*, whether as to the proportionate dimensions of the test or the disposition of the segments, are well exemplified by the drawings, Pl. LII. figs. 18, 19. In its typical condition, the species is represented by a slender Textulariform shell, either straight or somewhat bent, and composed of a larger number of segments than most of its congeners, often as many as twelve or fourteen in each row.

A very similar form was subsequently described by D'Orbigny under the name *Bolivina antiqua*. The figure is that of a shell with rather fewer chambers than the foregoing, and perhaps slightly more regularly Textularian in their arrangement; but it presents no distinctive character of even varietal value. Later authors have frequently used the term *Bolivina antiqua* for broad varieties having the contour of *Bolivina dilatata* and *Bolivina robusta*, but for this course there is no warrant in the original description. But more frequently the term *Bolivina antiqua* has been employed for fossil specimens, and *Bolivina punctata* for recent ones. The sooner this anomaly is removed the better; the latter was the name under which the form was first described, and it should take precedence.

Bolivina punctata is a cosmopolitan species. Its area of distribution extends from Smith Sound, lat. 79° 35′ N., and the shores of Novaya Zemlya, to Heard Island, in about lat. 53° S. It is found in the North and South Atlantic, in the North and South Pacific, in the Indian Ocean, the Red Sea, the Mediterranean, and the Arctic Ocean; and its bathymetrical range embraces every depth from 2 fathoms to 2750 fathoms.

It is nearly equally common in the fossil condition throughout the Tertiary epoch

from the London Clay and the early Tertiary beds of Hampshire to the Glacial deposits of the west of Scotland and elsewhere.

Bolivina dilatata Reuss (Pl. LII. figs. 20, 21).

Bolivina dilatata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 381, pl. xlviii. fig. 15.
„ „ Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 197, pl. ii. fig. 42.

This species differs from the more common *Bolivina punctata* in its broader proportions and acute peripheral edge, as well as in the comparatively long and narrow contour of its chambers. In addition to the figures given by the authors above quoted, there are a number of forms represented in the plates of the "Mikrogeologie," chiefly assigned by Ehrenberg to his genus *Grammostomum*, that might have been included in the synonymy; —such, for example, as *Grammostomum aciculatum*, pl. xx. II. fig. 10; *Grammostomum dilatatum*, pl. xxix. fig. 23; and *Grammostomum millepora*, pl. xxx. fig. 11.

The geographical distribution of *Bolivina dilatata* appears to be limited to the North Atlantic. It occurs in Challenger sands from the Azores, 450 fathoms, and from Bermuda, 435 fathoms; in three "Porcupine" dredgings from points to the west of Ireland, 183 to 1180 fathoms, and from one to the south of Ireland, 96 fathoms; and at one "Knight Errant" Station, in the cold area of the Faröe Channel, 540 fathoms. Messrs. Balkwill and Wright have obtained specimens from shallow water on the coast of Dublin and Wicklow.

As a fossil, it is not uncommon in the Miocene deposits of various parts of Austria (Reuss, Karrer), and in the later Tertiary sands of the neighbourhood of Rome (Terrigi).

Bolivina porrecta, H. B. Brady (Pl. LII. fig. 22, *a.b.c.*).

Bolivina porrecta, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 57.

Test elongate, straight, slightly tapering, somewhat compressed; margin and ends rounded. Segments about as broad as long, the earlier ones arranged on the normal Textularian plan, the later ones nearly triangular, and each extending the entire width of the test, the sutures forming a zigzag line from side to side. Walls thin and clear, very finely perforated; sutural depressions very slight. Aperture large, terminal, oblique. Length, $\frac{1}{30}$th inch (0·84 mm.).

Obtained at three localities, namely:—off Culebra Island, West Indies, 390 fathoms; off Tahiti, 420 fathoms; and in Humboldt Bay, north coast of Papua, 37 fathoms.

Bolivina textilarioides, Reuss (Pl. LII. figs. 23–25).

Bolivina textilaroides, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 81, pl. x. fig. 1.

Professor Reuss's specific name *Bolivina textilarioides*, may be conveniently accepted for those definitely Textulariform varieties, the segments of which are few in number as compared with *Bolivina punctata*, deep, and slightly inflated; the exterior smooth, the general contour relatively stout, and the margins rounded and more or less lobulated. Such forms are not uncommon in the recent condition, and have frequently been confounded with true *Textulariæ*.

The following list includes all the localities at which the occurrence of the species has been noted, but it is probably far from complete :—North Atlantic, west of Ireland, 183 fathoms, and south of Ireland, 96 fathoms; South Pacific, off Kandavu, Fiji Islands, three soundings, depths 218 fathoms, 253 fathoms, and 610 fathoms respectively; and Station 283, depth 2075 fathoms; and North Pacific, Honolulu Reefs, 40 fathoms.

It is occasionally met with both as a Cretaceous and Tertiary fossil.

Bolivina limbata, H. B. Brady (Pl. LII. figs. 26–28).

Bolivina limbata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 57.

Test elongate, tapering, compressed, more or less twisted; margin angular or only slightly rounded; segments large, distinct, sometimes gibbous. Sutures oblique, irregularly curved or sinute; limbate externally, especially near the points of contact between the two series of segments on both faces of the test. Length, $\frac{1}{35}$th inch (0·75 mm.).

The twisted varieties of *Bolivina* with nearly even margins and limbate sutures, on which this species has been founded, affect the comparatively shallow water of tropical seas. They are abundant around the Island of Papua, occurring at almost every Station in its immediate vicinity at which the depth does not exceed 200 fathoms. The same forms occur off the Sandwich Islands, 40 fathoms; in Hong Kong harbour, 7 fathoms; on the south shores of Japan, 15 fathoms; off the Fiji Islands, 12 fathoms; on the Australian coral-reefs, 14 to 17 fathoms; in shore-sands from Madagascar; off Ascension Island, 7 fathoms; and off the Cape de Verde Islands, 11 fathoms.

Bolivina tenuis, H. B. Brady (Pl. LII. fig. 29).

Bolivina tenuis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 57.

Test thin, outspread, broadly elliptical, slightly convex on both sides; margin acute. Segments few in number, long, curved, obliquely set; each with a sort of supplementary lobe, the lobes collectively presenting the appearance of a series of chamberlets down the

median line. Aperture on the oblique face of the terminal chamber, surrounded by radiating lines. Dimensions, $\frac{1}{80}$th by $\frac{1}{100}$th inch (0·3 by 0·25 mm.).

This is a very minute species, but interesting alike from the peculiarity of its contour and the apparent subdivision of the segments near the median line. A somewhat similar condition of the segments is seen in an elongate tapering variety of *Bolivina* figured by Ehrenberg (Mikrogeologie, pl. xxv. fig. 16) under the name "*Grammostomum polytheca*?"

Bolivina tenuis has only been met with at a single locality,—off Kandavu, Fiji Islands, 255 fathoms.

Bolivina nitida, n. sp. (Pl. LII. fig. 30, *a.b.*).

Bolivina lævigata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 57.

Test elongate, thin, complanate, broadest at the centre, tapering and rounded towards the ends. Segments few in number, regularly Textularian in arrangement; broad, flattened on both faces, and bordered both at sutures and periphery by a narrow band of clear shell-substance. Sutures even; aperture large, irregularly oval, oblique. Length, $\frac{1}{60}$th inch (0·42 mm.).

This species was originally described under the name *Bolivina lævigata*, but as that term had been previously employed by Karrer for a different form, a fresh designation has become needful.

Found off East Moncœur Island, Bass Strait, 38 fathoms; and off Raine Island, Torres Strait, 155 fathoms; rare in both localities.

Bolivina tortuosa, H. B. Brady (Pl. LII. figs. 31–34).

Bolivina tortuosa, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 57.

Test elongate, tapering, broadest near the apertural end; the margins bent obliquely towards the median line on either side, so as to give to the entire shell a twisted contour; peripheral edge thin, sharp, lobulated. Segments numerous; long and narrow; the later ones projecting and rounded at the peripheral ends. Shell conspicuously perforated. Length, $\frac{1}{60}$th inch (0·42 mm.) more or less.

This species varies a good deal both as to size and contour. The figures 31, 32 and 33, 34 represent average specimens from two different localities at which it occurs in considerable abundance; the former from the Admiralty Islands, 17 fathoms, the latter from the Cape de Verde Islands, 11 fathoms. Near the Cape de Verde Islands it is also found in

much deeper water. It has been observed in addition at the following localities:—off Ascension Island, 420 fathoms; Simon's Bay, Cape of Good Hope, 15 to 20 fathoms; Port Louis, Mauritius, harbour-mud; off Calpentyn, Ceylon, 2 fathoms; and off the Fiji Islands, 12 fathoms and 210 fathoms.

Bolivina pygmæa, H. B. Brady (Pl. LIII. figs. 5, 6).

Bolivina pygmæa, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 57.
„ „ Id. 1882, Proc. Roy. Soc. Edin., vol. xi. p. 711, table.

Test minute; short, broad, biconvex; widest near the oral end, and tapering to a point at the aboral extremity. Segments numerous, distinct, somewhat inflated; the peripheral ends of the later chambers extended into sharp projecting points directed obliquely or horizontally. Length, $\frac{1}{100}$th inch (0·25 mm.).

Occurs in sands dredged off Gomera, Canary Islands, 620 fathoms; off Prince Edward Island, 50 to 150 fathoms; off Nightingale Island, Tristan d'Acunha, 100 to 150 fathoms; and in the Faröe Channel, 530 and 540 fathoms. In the Rev. A. M. Norman's collection there are specimens from Oster Fiord, near Bergen, Norway, 100 to 200 fathoms.

Bolivina robusta, H. B. Brady (Pl. LIII. figs. 7–9).

Bolivina robusta, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 57.

Test regularly Textularian; elongate, compressed; broad and rounded at the oral extremity; tapering to a point, and frequently terminating in a long stout spine, at the aboral end. Test thickest on the median line, and sloping away symmetrically towards the lateral edges; margin subacute. Segments numerous, about ten in each series; long, curved, obliquely set. Shell stoutly built; sutures thickened, usually limbate and somewhat crenulate externally. Length, $\frac{1}{45}$th inch (0·56 mm.), exclusive of the terminal spine.

The distribution-list of *Bolivina robusta* includes twenty-two localities, and of these, thirteen are in the South Pacific, with depths ranging from 10 fathoms or less to 800 fathoms. The remainder are as follows:—three in the North Pacific, 7 fathoms to 345 fathoms; two off the Cape of Good Hope, 15–20 fathoms, and 150 fathoms; and two in the South Atlantic, 675 fathoms, and 1900 fathoms respectively. In the North Atlantic I have only met with the species at one Station, off the Cape de Verde Islands, 11 fathoms; but the Rev. A. M. Norman has specimens, dredged in Oster Fiord near Bergen, Norway, at depths of 100 to 200 fathoms.

Bolivina beyrichi, Reuss (Pl. LIII. fig. 1).

Bolivina beyrichi, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 83, pl. vi. fig. 51.
„ „ Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 64, pl. vii. fig. 11.
„ , Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 198, pl. ii. fig. 44.

The *Bolivina beyrichi* of Reuss is closely allied to *Bolivina gramen* (*Vulvulina gramen*, d'Orbigny,—Foram. Cuba, p. 139, pl. i. figs. 30, 31). The principal grounds of distinction are the somewhat narrower, more slender contour of Reuss's species, and the greater depth and subtriangular outline of its later chambers, but these are at best very variable characters. In both organisms the inferior peripheral angles of the segments project, and are drawn out into sharp points which are directed towards the initial end of the test. This peculiarity constitutes their most striking feature; and it may be a question whether it is worth while to preserve a "specific" separation between two forms so similar in their salient characters.

Bolivina beyrichi occurs at the following Stations:—off the Canaries, 600 fathoms and 1125 fathoms; off Sydney, 410 fathoms; off the Ki Islands, 129 fathoms and 580 fathoms; off the Philippines, 95 fathoms; on the *Hyalonema*-ground, south of Japan, 345 fathoms; and on the Pacific shores of Patagonia, 120 fathoms and 345 fathoms.

In the fossil condition, it is a frequent constituent of the Septaria-clays of Germany (Reuss), and of the lower *Clavulina-szabói* beds of Hungary (Hantken), as well as of the later Tertiary sands of the neighbourhood of Rome (Terrigi).

Bolivina beyrichi, var. *alata*, Seguenza (Pl. LIII. figs. 2–4).

Vulvulina alata, Seguenza, 1862, Atti dell' Accad. Gioenia, ser. 2, vol. xviii., p. 113, pl. ii. figs. 5, 5*a*.
Bolivina beyrichi, var. *carinata*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 64, pl. vii. fig. 12.
„ „ „ Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii., p. 198, pl. ii. figs. 43, 45.

As the name implies, this is a modification of *Bolivina beyrichi*, characterised by the thinning out of the lateral margins of the test, so as to form a well-defined peripheral wing or keel. The entire test is somewhat broader proportionately than that of the type, and the wing is of variable form and dimensions.

Such shells are often met with, both in the recent and fossil condition, wherever the typical form is plentiful. Good specimens have been noticed at the following amongst other localities:—off Aru Island, 800 fathoms; off the Philippine Islands, 95 fathoms; off Raine Island, 155 fathoms; off Kandavu, 210 fathoms; and off Cezimbra, south of Lisbon, 50 fathoms.

Bolivina œnariensis, Costa, sp. (Pl. LIII. figs. 10, 11).

Brizalina œnariensis, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 297, pl. xv. fig. 1, *A. B.*
Bolivina œnariensis, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 711—Table.

So far as can be made out from the drawing, the shell described by Costa in the Paleontologia del regno di Napoli, *loc. cit.*, under the name *Brizalina œnariensis*, is a tolerably regular, elongate, compressed, tapering *Bolivina*, with entire margin and sharp peripheral edges, and terminating in a spine at the initial end. Two lines traversing the face of the test longitudinally, described by the author as two internal tubular syphons, have the appearance of delicate costæ, and closely resemble the central riblets of fig. 11. The similarity of *Brizalina* to *Bolivina* in all important characters is admitted in the description of the genus; and it may be observed that the superficial costæ are of little value as a distinctive feature of the species, inasmuch as they vary both in number and in length, and are sometimes entirely wanting.

The best specimens of *Bolivina œnariensis* hitherto met with in the recent condition are from the North Atlantic. It is not uncommon in dredged material from the area lying west and north-west of Ireland, and from the Faröe Channel, at depths ranging from 85 fathoms to 1630 fathoms. Less characteristic examples have been obtained from the Philippine Islands, 95 fathoms; from the south coast of Japan, 15 fathoms; and off the mouth of the Rio de la Plata, 13 fathoms.

Costa's specimens were from the later Tertiary beds of Casamicciola in the Island of Ischia.

Bolivina decussata, H. B. Brady (Pl. LIII. figs. 12, 13).

Bolivina decussata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 58.

Test elongate, compressed; broad and obliquely truncate at the oral end, and tapering to a rounded point at the aboral extremity; peripheral edge thick, square or slightly rounded, lobulated. Segments numerous, nine or ten in each series; septation indistinct or entirely concealed externally. Surface beset with low prominences or bosses, which are rounded or subangular in outline, and arranged with some regularity in oblique rows, about four to each row. Length, $\frac{1}{50}$th inch (0·5 mm.).

This somewhat striking little species occurs at two points in the South Pacific, namely, —at Station 300, north of Juan Fernandez, depth 1375 fathoms, where it is abundant, and at Station 302, south-west of the same island, depth 1450 fathoms, where it is comparatively rare.

Bolivina nobilis, Hantken (Pl. LIII. figs. 14, 15).

Bolivina nobilis, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 65, pl. xv. fig. 4, *a. b.*

In general contour, in the form and arrangement of the segments, and in the surface-ornament of delicate, parallel, longitudinal striæ, the recent examples of this species agree accurately with von Hantken's description and figure; but such as have been hitherto obtained are not as a rule so large as the fossil specimens.

So far as can be learnt from the Challenger dredgings, the occurrence of *Bolivina nobilis* is confined to the South Pacific. The following are the localities at which it has been collected:—Humboldt Bay, Papua, 37 fathoms; Nares Harbour, Admiralty Islands, 17 fathoms; off Tahiti, 420 fathoms; off Levuka, Fiji, 12 fathoms; and Port Jackson, 6 fathoms.

Von Hantken's specimens were from the later *Clavulina-szabói* formation of Ofen (Buda), Hungary.

Bolivina hantkeniana, H. B. Brady (Pl. LIII. figs. 16–18).

Bolivina hantkeniana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi. N. S., p. 58.

Test depressed, nearly equally convex on the two faces; varying in contour, from a relatively long form tapering to a point at the aboral extremity, to a broadly oval modification with rounded ends. Composed of numerous, rounded, inflated segments, in two more or less regular alternating series, surrounded by a delicate keel of varying width and completeness. Aperture oval; with a thickened lip or border, and often furnished with a projecting tongue. Surface generally traversed by short, delicate, longitudinal costæ. The long narrow specimens which seldom have a continuous wing attain a length of $\frac{1}{30}$th inch (0·84 mm.) or more; whilst those of wider proportions with the broader more regular wing are less than $\frac{1}{40}$th inch long (0·6 mm.) and about $\frac{1}{50}$th inch (0·5 mm.) broad.

Bolivina hantkeniana is a polymorphic species, and its range of variation is suggested rather than fully represented by the drawings.

Its area of distribution appears to be limited to the islands of the Pacific, the following being the only localities at which it has been observed:—off Tahiti, 420 fathoms and 620 fathoms; off Kandavu, 210 fathoms and 255 fathoms; off New Hebrides, 130 fathoms; and off Aru Island, 800 fathoms.

Bolivina karreriana, H. B. Brady (Pl. LIII. figs. 19–21).

Bolivina karreriana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 58.

Test elongate, tapering, broadest near the oral end, somewhat depressed; aboral extremity pointed, often mucronate; peripheral edge thick and rounded, more or less

lobulated. Surface of the test ornamented with numerous delicate, often branching or otherwise irregular, longitudinal ribs. Segments inflated; aperture large, oblique, bordered by a thickened lip. Length, $\frac{1}{40}$th inch (0·63 mm.).

This pretty species is abundant on the *Hyalonema*-ground, south of Japan, 345 fathoms. It occurs also in the South Pacific, at two points off Tahiti, 420 fathoms and 620 fathoms respectively; and in the South Atlantic, off Pernambuco, 675 fathoms.

Bolivina lobata, H. B. Brady (Pl. LIII. figs. 22, 23).

Bolivina lobata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 58

Test elongate, depressed, digitate; distal end obliquely truncate or rounded, aboral extremity obtuse, peripheral edge lobulated. Segments inflated, their outer margins projecting and subangular; sutures thickened, and deeply sunk; surface especially of the later chambers more or less granulated. Aperture a long oval slit contracted at the middle; nearly central. Length, $\frac{1}{60}$th inch (0·4 mm.).

Bolivina lobata has been obtained from four localities, all of which are near the Island of Papua,—two of them off the Admiralty Islands, 16 to 25 fathoms; the others, Humboldt Bay, 37 fathoms, and Torres Strait, 155 fathoms.

Bolivina lobata, var. *strigosa*.—A clear-shelled variety of this species, with somewhat exaggerated peculiarities, occurs off Raine Island, Torres Strait. This is figured in Pl. CXIII. fig. 7, and may be distinguished as *Bolivina lobata*, var. *strigosa*. The specimens are of about the same length as those of the type, but much attenuated; the chambers are subtriangular, the inferior angles acute and projecting, and directed either outwards or towards the initial end of the test. It is less distinctly Textulariform than *Bolivina lobata*, quite hyaline in texture, and free from superficial granulation.

Bolivina schwageriana, H. B. Brady (Pl. LIII. figs. 24, 25).

Bolivina schwageriana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 58.

Test oblong, biconvex, broadest near the middle, tapering to a blunt point at the initial extremity; margin carinate. Keel widest near the middle of the shell, absent at the initial end. Sutures limbate, the limbation taking the form of raised beads or irregular lines of shell-substance on both sides of the test, chiefly near the points of contact of the two opposing series of segments; surface otherwise smooth. Aperture large, with an oblique projecting tooth near the anterior end. Length, $\frac{1}{45}$th inch (0·56 mm.); breadth near the middle of the test only slightly less.

The figured specimens were obtained, amongst others, from Humboldt Bay, Papua, 37 fathoms; besides which, a few somewhat doubtful examples have been found at Station 185, off Raine Island, Torres Strait, 155 fathoms.

Bolivina costata, d'Orbigny (Pl. LIII. figs. 26, 27).

Bolivina costata, d'Orbigny, 1839, Foram. Amér. Mérid., p. 62, pl. viii. figs. 8. 9.

Most of the Challenger specimens of this species differ from the typical shell figured by d'Orbigny, *loc. cit.*, in their more broadly oval outline, and in the smaller number of segments of which the test is composed. These, however, are comparative characters of no great importance.

The oval variety above referred to occurs off Raine Island, Torres Strait, 155 fathoms; in Humboldt Bay, Papua, 37 fathoms; and off Amboyna, 15 to 20 fathoms.

The habitat given by d'Orbigny for the typical form is the Harbour of Cobija in Bolivia, where it is stated to be common. In Prof. W. K. Parker's collection are a few small but characteristic specimens, from shallow-water pools at Eastbourne, Sussex.

Bolivina amygdalæformis, H. B. Brady (Pl. LIII. figs. 28, 29).

Bolivina amygdalæformis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 59.

Test oval, compressed, almond-shaped; ends obtuse or rounded, peripheral edge rounded. Segments few; septation obscured by a surface ornamentation of stout, branching, longitudinal costæ. Terminal chamber nearly smooth and conspicuously perforated. Aperture central, of long oval form, slightly constricted at the middle. Length, $\frac{1}{36}$th inch (0·72 mm.).

Found in sands dredged off the Philippine Islands, 95 fathoms; off the Admiralty Islands, 16 to 25 fathoms; off the north coast of Papua, 1070 fathoms; and in Torres Strait, 155 fathoms.

Bolivina reticulata, Hantken (Pl. LIII. figs. 30, 31).

Bolivina reticulata, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 65, pl. xv. fig. 6, *a.b.*

This species has a minute few-chambered test, of compressed rhomboidal shape, ornamented externally with an irregular network of raised lines. In the recent condition it seldom exceeds $\frac{1}{70}$th inch (0·36 mm.) in length, but fossil specimens attain somewhat larger dimensions. I am indebted to my friend Herr v. Hantken for examples of the form as it exists in the Hungarian Tertiaries, and a comparison of these with the living shells obtained from the Challenger dredgings leaves no doubt that both belong to the same species.

The best recent specimens of *Bolivina reticulata* are from the following localities in the South Pacific:—off New Hebrides, 130 fathoms; off Raine Island, 155 fathoms; off Kandavu, 255 fathoms; and off Tahiti, 420 fathoms. It occurs also in the South Atlantic, mid-ocean, 1425 fathoms. Specimens with intermediate characters, somewhat resembling *Bolivina decussata*, have been met with at Station 144, between the Cape of Good Hope and Kerguelen Island, 1570 fathoms.

Von Hantken states that the species is not uncommon in both the upper and lower *Clavulina-szabói* formations of Hungary.

Bolivina subangularis, H. B. Brady (Pl. LIII. figs. 32, 33).

Bolivina subangularis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 59

Test oblong, tapering, stoutly built, more or less angular, somewhat concave or excavated on both sides; aboral extremity obtusely pointed. The angular contour of the transverse section is determined by the prominence of superficial costæ, the principa of which, six in number, are placed, one down each lateral margin and two down each face of the test. Aperture comma-shaped. Length, $\frac{1}{50}$th inch (0·5 mm.) or less.

A rare variety, nearly allied to *Bolivina costata*. It occurs at Station 209, Philippine Islands, 95 fathoms, and at Station 185, off Raine Island, 155 fathoms.

Sub-family 3. Cassidulininæ.

Cassidulina, d'Orbigny.

Cassidulina, d'Orbigny [1826], Bronn, Reuss, Egger, Parker and Jones, Williamson, Carpenter Brady, M. Sars, Alcock, Winther, Schulze, Hantken, &c
Burseolina, Seguenza [1880].

The arrangement of the test in *Cassidulina* is in some respects more complex than that of any other type of Foraminifera, inasmuch as it combines two distinct modes of growth, the biserial and the convoluted. This may be best understood by its analogy, in the typical condition, to a broad Textularian or Bolivine shell, doubled or folded longitudinally on the median line, and then rolled in the crease so formed from the narrow to the broad end. The flaps of each convolution extend nearly or quite to the umbilicus, and completely enclose the previous whorls. The aperture is an oblique loop-like opening, resembling that of *Bulimina*.

If the normal plan of growth be borne in mind, it is easy to understand its modifications, as represented in the commoner species, by reference to those of one of the simple planospiral types, such as *Cristellaria*. Thus, both in *Cassidulina* and *Cristellaria* there are lenticular varieties which have a sharp peripheral edge, oval and compressed

varieties with an obtuse or rounded margin, and subglobular forms. The former genus also furnishes isomorphs of the elongate partially uncoiled species of *Cristellaria*, such as *Cristellaria crepidula* and *Cristellaria obtusata;* and the question has arisen whether these should be retained amongst the typical *Cassidulinæ*, or transferred to the genus *Ehrenbergina* described on a later page; but, as in the case of *Cristellaria*, it has been found impossible to separate such forms from the strictly convolute varieties; and the precedent established in that genus has therefore been followed.

There is, however, one modification of the type which is non-spiral throughout, and which bears about the same relation to *Cassidulina* that *Nodosaria* bears to *Cristellaria*. Specimens of this nature are exceedingly rare; and, pending the discovery of sufficient material for the full elucidation of their structure, they have been assigned provisionally to a new sub-genus *Orthoplecta* (ὀρθός, straight, and πλεκτος, plaited).

The test of *Cassidulina* is invariably perforate. The walls are thin, calcareous, hyaline, smooth externally, and free from surface-ornament of any kind.

The distribution of living *Cassidulinæ* is world-wide, almost irrespective of latitude or depth. In the fossil condition the genus is not very common; it makes its appearance in the Eocene period, and is represented from time to time in beds of later geological age.

Cassidulina lævigata, d'Orbigny (Pl. LIV. figs. 1–3).

Cassidulina lævigata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 282, pl. xv. figs. 4, 5;—Modèle, No. 41.
„ *pulchella*, Id. 1839, Foram. Amér. Mérid., p. 57, pl. viii. figs. 1–3.
„ *punctata*, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 367, pl. xlviii. fig. 4, *a.b.*
„ *lævigata*, Williamson, 1858, Rec. For. Gt. Br., p. 68, pl. vi. figs. 141, 142.
„ *sicula*, Seguenza, 1862, Atti dell' Accad. Gioenia, ser. 2, vol. xviii., p. 109, pl. i. figs. 7, 7*a*.
„ *lævigata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 377, pl. xvii. fig. 64, *a.b.c.*

The test of the typical *Cassidulina lævigata* is nearly circular in outline, biconvex or lenticular, and has a thin, often slightly carinate, peripheral edge. The segments are numerous, long, narrow, much curved, and scarcely at all inflated; and the sutures are but little excavated on the exterior. In some specimens the shell-perforation is scarcely visible, in others the pores are numerous and conspicuous. The peripheral keel never amounts to a feature of any importance, as in *Cristellaria* and some other genera; at best it is very narrow and ill-defined, and seldom completely encircles the test; in rare examples (fig. 3) it is more or less serrate or jagged. None of the various "species" enumerated in the foregoing synonymy present characters differing in any material respect from the type, nor have they any claim to be considered as even varietally distinct.

Cassidulina lævigata is distributed, though by no means evenly, over a very wide area. It is one of the commonest of all arctic Foraminifera, occurring at almost every point at which soundings have been taken within the Arctic Circle. In the western hemisphere it has been found as far north as lat. 83° 19′ N.; and in the eastern, to the shores of Franz-Josef Land, at about lat. 80° N. It is abundant over the whole northern portion of the North Atlantic, at depths ranging from 60 to 1600 fathoms, diminishing in frequency towards the equator, and is found in shallow water along the European coast-line. It is comparatively rare in the South Atlantic, but occurs off the Cape of Good Hope and in the Southern Ocean as far as the Antarctic Ice-barrier, lat. 65° 42′ S.; it is frequently met with amongst the islands of the South Pacific, at depths of less than 600 fathoms, being especially common amongst those of the west coast of Patagonia; and it has also been obtained at three localities in the North Pacific: lastly, it has been collected both in the Mediterranean and the Red Sea.

The geological distribution of the species does not extend further back than the beginning of the Tertiary epoch. It has been found in the London Clay of the Isle of Wight (Brady); in the Middle Tertiaries of various parts of Austria and Hungary (Reuss); in the later Tertiary formations of Central and Southern Italy (Jones and Parker, Seguenza, Terrigi); in the Crag of the eastern counties of England (Jones, Parker, and Brady); and in the Post-tertiary deposits of Norway (Sars, Crosskey and Robertson), of Ireland (Wright), and of the Island of Ischia (Vanden Broeck).

Cassidulina crassa, d'Orbigny (Pl. LIV. figs. 4, 5).

Cassidulina crassa, d'Orbigny, 1839, Foram. Amér. Mérid., p. 56, pl. vii. figs. 18–20.
„ „ Id. 1846, For. Foss. Vien., p. 213, pl. xxi. figs. 42, 43.
„ *oblonga*, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 376, pl. xlviii. figs. 5, 6.
„ *obtusa*, Williamson, 1858, Rec. For. Gt. Br., p. 69, pl. vi. figs. 143, 144.
, *lævigata*, var. *crassa*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 377, pl. xv. figs. 5–7; pl. xvii. fig. 64, *d*.
„ *oblonga*, Jones, Parker, and Brady, 1865, Monogr. Foram. Crag, App. I. II. pl. iv. fig. 16.
„ *crassa*, Id. Ibid. App. I. II.

The test of *Cassidulina crassa* is characterised by its oval outline and obtuse or rounded peripheral edge. It is relatively thicker than *Cassidulina lævigata*, and the segments are fewer in number, and comparatively short and inflated.

I can find no ground of distinction between this species and the *Cassidulina oblonga* of Reuss. The slight differences that appear in the figures are only such as may be observed in any collection of specimens, even from the same locality, and amount to no more than individual peculiarities. The species varies within certain limits, both in point of

size and in the number and contour of the visible segments, but not to an extent that interferes with its easy identification.

The geographical range of *Cassidulina crassa* is as wide as that of *Cassidulina lævigata*, and it appears to be much more evenly distributed than the latter form. It was one of the Foraminifera obtained at the most northerly point reached on the last British North-Polar Expedition, in lat. 83° 19′ N., and has also been found on the shores of Franz-Josef Land and Spitzbergen. It is scattered over the whole of the North Atlantic, even to depths as great as 2760 fathoms, and occurs at six Challenger Stations in the South Atlantic. It is found off the Cape of Good Hope, and thence all the way, by Kerguelen and the Heard Islands, to the Antarctic Ice-barrier. It has been noticed at fifteen Stations in the South Pacific, at depths varying from 210 fathoms to 2075 fathoms, and at five in the North Pacific, from 40 fathoms to 2475 fathoms. It has also been obtained from many parts of the Mediterranean.

As a fossil its earliest recorded appearance is in the Middle Tertiaries of Austria and Hungary (Reuss), and of Lower Bavaria (Egger). It occurs in the Subapennine clays of Italy (Jones and Parker); in the Crag of the eastern counties of England (Jones, Parker, and Brady); and in the Post-tertiary deposits of Norway (Sars, Crosskey and Robertson) and of the north-east of Ireland (Wright).

Cassidulina subglobosa, H. B. Brady (Pl. LIV. fig. 17, *a.b.c.*).

Cassidulina subglobosa, Brady, 1881, Quart. Journ. Sci., vol. xxi., N. S, p. 60.

Test subglobular, somewhat compressed on the two lateral faces, inequilateral; segments few, slightly inflated; alternation irregular. Aperture an oblique or nearly erect loop-like slit on the face of the projecting terminal segment. Longer diameter, $\frac{1}{37}$th inch (0·7 mm.).

This form has characters in some respects intermediate between those of *Cassidulina crassa* and *Cassidulina calabra*, but may be distinguished from either by its relatively large size, and the irregularity displayed in the general contour of the test, the alternation of the segments, and the shape and insertion of the aperture.

Cassidulina subglobosa occurs in all the great ocean-basins, and is for the most part a deep-water species. Its distribution-list includes nine Stations in the North Atlantic, between lat. 40° N. and the equator, the depths ranging from 435 to 2750 fathoms; four Stations in the South Atlantic, 350 to 1035 fathoms; three in the Southern Ocean, 120 to 1950 fathoms; twelve in the South Pacific, 12 to 2350 fathoms; and two in the North Pacific, 2300 and 2950 fathoms respectively.

Cassidulina calabra, Seguenza, sp. (Pl. CXIII. fig. 8, *a.b.c.*).

Burseolina calabra, Seguenza, 1879, Formaz. Terz. Reggio, p. 138, pl. xiii. fig. 7, *a.b.*

Prof. Seguenza has had the goodness to send to me for examination specimens of the Miocene Foraminifer named by him *Burseolina calabra*. Owing to their fossilised condition, the septation of the shells is more or less obscure, and in this respect their structure is not quite correctly rendered by the drawings that accompany his description of the species (*loc. cit.*). A comparison with recent specimens leaves no doubt that the Tertiary form is identical in all important characters with the globular variety of *Cassidulina* represented in Pl. CXIII. fig. 8.

Von Hantken has described an oval, somewhat compressed *Cassidulina*, from the Hungarian Tertiaries, under the name *Cassidulina globosa* (Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 64, pl. xvi. fig. 2, *a.b.*), but this appears to be an intermediate variety, scarcely separable from *Cassidulina crassa*. The specimens figured by Egger with the name *Cassidulina globulosa* (Neues Jahrb. für Min., &c., 1857, p. 296, pl. xi. figs. 4–7), are evidently *Globigerinæ*, and probably belong to more than one species.

In the living state *Cassidulina calabra* has only been met with at two points, namely:—off Raine Island, Torres Strait, 155 fathoms; and off Kandavu, Fiji Islands, 610 fathoms.

Seguenza's fossil specimens were from the Upper Miocene of Reggio, Calabria.

Cassidulina bradyi, Norman (Pl. LIV. figs. 6–10).

Cassidulina bradyi (Norman, MS.) Wright, 1880, Proc. Belfast Nat. Field Club.—App., p. 152.
„ „ Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 59.

Test spiral, compressed; oval, reniform, or crosier-shaped; lateral faces convex, peripheral edge thin, sharp or slightly rounded. Early segments planospiral, embracing, arranged on the normal Cassiduline plan; later segments oblique, alternating, forming a straight or curved biserial line. Aperture loop-shaped, situated on the inner face of the terminal chamber. Length, $\frac{1}{60}$th inch (0·42 mm.).

This species was discovered many years ago by the Rev. A. M. Norman, and in the absence of any published description has been referred to by subsequent authors under his manuscript name.

Morphologically, *Cassidulina bradyi* bears somewhat the same relation to the typical *Cassidulina lævigata*, that *Cristellaria crepidula* or *Cristellaria obtusata* bears to *Cristellaria rotulata*; in others words, the later portion of the test exhibits a tendency to form a straight or curved line instead of continuing the spiral mode of growth. In localities where the species is plentiful, the specimens show a great variety of contour, some, like fig. 10, being not much longer proportionately than *Cassidulina*

crassa, though easily distinguished from that form; whilst others, such as those portrayed by figs. 7 and 8, have the narrow linear aspect already alluded to.

Cassidulina bradyi is not uncommon in the "Porcupine" dredgings to the west and south of Ireland, at depths ranging from 90 to 1630 fathoms; but it does not inhabit the more southern area of the North Atlantic traversed by the Challenger, nor has it been found in the South Atlantic. It occurs at five localities in the South Pacific, 155 to 610 fathoms; and at two in the North Pacific,—off the Philippine Islands, 95 fathoms, and off the south coast of Japan, 345 fathoms.

Cassidulina parkeriana, H. B. Brady (Pl. LIV. figs. 11–16).

Cassidulina parkeriana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 59.

Test crosier-shaped, coiled at the commencement, subsequently rectilinear or arcuate; earlier portion planospiral, often relatively very small, the chambers arranged as in *Cassidulina crassa;* linear portion cylindrical, nearly round in transverse section, composed of numerous short ventricose segments, arranged as in *Textularia* in two alternating series. Aperture comma-shaped, situated on the inner face of the ultimate segment, at the distal end of the test. Length, $\frac{1}{45}$th inch (0·57 mm.) more or less.

This interesting dimorphous form has only been taken at three localities, amongst the Islands on the west coast of Patagonia:—namely, Stations 304, 305, and 308, depths, 45 fathoms, 160 fathoms, and 175 fathoms respectively.

Cassidulina (*Orthoplecta*) *clavata*, nov. (Pl. CXIII. fig. 9).

Test elongate, cylindrical, more or less bent, slightly tapering, thickest near the distal end, extremities rounded; consisting of numerous short segments of unequal size and variable form, combined in an irregularly alternating or subspiral manner. Septa distinct externally, but not marked by depressions. Aperture an oblique loop-like opening on the face of the final segment close to the distal end. Length, $\frac{1}{50}$th inch (0·5 mm.).

This interesting form may be taken as an illustration of the extreme modification in one direction of the Cassiduline series. It represents the Nodosariform condition of the type, just as *Cassidulina parkeriana* represents the Marginuliniform mode of growth. The foregoing zoological characters are given with a certain amount of reservation, but they embrace what appear to be the salient features of the organism, so far as can be made out from the scanty material at present available.

Cassidulina (*Orthoplecta*) *clavata* has only been found at a single locality, namely, Nares Harbour, Admiralty Islands; depth, 17 fathoms.

Ehrenbergina, Reuss.

Cassidulina, pars, d'Orbigny [1839], Carpenter, Parker and Jones.
Ehrenbergina, Reuss [1849], Karrer, Parker and Jones, Brady.

The typical form of the test in the genus *Ehrenbergina* may be compared to that of a *Cassidulina* which has been opened out and partially or entirely unrolled. The shell is broad at the distal end, and the regular Textularian arrangement of the segments is distinctly shown, especially on the convex or dorsal face; the ventral face is more or less concave. In well-marked specimens the lateral margins are thin and often serrate; but occasionally they are obtuse and rounded, and in such cases the form of the test approximates to that of the true *Cassidulinæ*.

The distinction between *Ehrenbergina* and the elongated varieties of *Cassidulina* is by no means strongly defined. It rests chiefly on the fact that in *Ehrenbergina* the line of segments appears to be unfolded laterally as well as uncoiled vertically, and that the segments are inequilateral, differing in form on the ventral and dorsal faces of the test.

Geographically the occurrence of living *Ehrenberginæ* is almost confined to the southern hemisphere, though specimens have been found at one or two points in the tropical part of the North Atlantic, and at a single Station in the North Pacific. The genus is tolerably common both in the South Atlantic and in the South Pacific, and has a very wide bathymetrical range. The only known fossil representatives are rare specimens of Miocene age from the neighbourhood of Vienna.

Ehrenbergina pupa, d'Orbigny, sp. (Pl. LV. fig. 1, *a.b.*, Pl. CXIII. fig. 10, *a.b.c.*).

Cassidulina pupa, d'Orbigny, 1839, Foram. Amér. Mérid., p. 57, pl. vii. figs. 21–23.

This is the simplest exemplification of the generic characters, and its affinity to the typical *Cassidulinæ* is easily recognised. It differs from its congeners in the even or slightly lobulated condition of the lateral edges, and in the entire absence of sharp angles or spines.

Ehrenbergina pupa is a comparatively rare species, and with the exception of a single locality in the North Atlantic—off the Azores, 450 fathoms—has only been found on the shores of South America. D'Orbigny's original specimens were obtained from the Falkland Islands, and it is a matter of some interest that it has again been collected in their immediate vicinity, namely, at Station 317, depth 1035 fathoms. The remaining localities are Stations 321, mouth of Rio de la Plata, 13 fathoms; and two points on the west coast of Patagonia, 120 fathoms and 175 fathoms respectively.

Ehrenbergina serrata, Reuss (Pl. LV. figs. 2–7).

Ehrenbergina serrata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 377, pl. xlviii. fig. 7, *a.–c.*

Prof. Reuss's figures (*loc. cit.*), though tolerably characteristic, represent only a poor specimen of this somewhat variable species. The salient character of *Ehrenbergina serrata*, that by which it is distinguished from *Ehrenbergina pupa*, consists in the extension outwards of the lateral margins of the chambers, so as to form projecting angles, in consequence of which the test presents a serrate outline. In some cases the angles terminate in slightly deflected points, as shown in Pl. LV. figs. 2, 3, but in others they are much produced, and take the shape of long horizontal spines, as in figs. 6, 7. Nor is this all. In Reuss's drawings the ventral faces of the segments are inflated and rounded in much the same way as those of *Ehrenbergina pupa;* but in well-developed examples the convex face as well as the margin of each chamber is drawn out to a point, so that there are two rows of short spines on the ventral face of the test, one row at each side of the depressed median line.

The dorsal side of the shell is smooth and shows very distinctly the regular, alternate arrangement and interdigitation of the segments. There are no depressions on the septal lines, and the surface is free from spines or other excrescences.

It is singular that *Ehrenbergina serrata* has not before been recorded as a recent species; for, though it can scarcely be classed amongst common Foraminifera, it occurs at intervals over a very wide area. Amongst the Challenger gatherings it has been identified at two localities in the North Atlantic:—off the Azores, 450 fathoms, and off the Canaries, 620 fathoms; at two in the South Atlantic, in mid-ocean, 1025 fathoms and 2350 fathoms respectively; and at one in the North Pacific, 2340 fathoms. In the South Pacific it is comparatively frequent, having been found at no less than ten Stations, varying in depth from 150 to 2075 fathoms.

The species was originally described from fossil specimens obtained by Reuss from the Miocene of Baden near Vienna, and Karrer reports its occurrence also at Nussdorf, in the same vicinity.

Ehrenbergina hystrix, H. B. Brady (Pl. LV. figs. 8–11).

Ehrenbergina hystrix, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 60.

Test biserial, earlier portion more or less coiled; somewhat ovate in general contour, distal end broad and arched. Segments few; regular and alternate in their dorsal aspect, confused on the ventral face; their free peripheral ends drawn out into lateral spines. The sutural lines of the earlier segments on the dorsal face marked with rows of spines, which sometimes coalesce so as to form fringe-like projections; the ventral

surface of the early segments also beset with stout spines or tubercles. Aperture large, curved; placed obliquely in a depression on the inflated distal end of the terminal segment, which is ornamented externally with radiating lines. Length, $\frac{1}{33}$rd inch (0·77 mm.).

Ehrenbergina hystrix differs from its congeners in the spinous condition of the lateral faces of the test, and in its large inflated final segment.

It is a rare deep-water species, and has only been found hitherto at four points in mid-ocean in the South Pacific, namely:—Station 179, depth, 2325 fathoms; Station 271, depth, 2425 fathoms; Station 280, depth, 1940 fathoms; and Station 283, depth, 2075 fathoms.

Family VI. CHILOSTOMELLIDÆ.

The Family Chilostomellidæ embraces the three genera *Chilostomella*, *Allomorphina*, and *Ellipsoidina*, and is equivalent therefore to Reuss's Family Cryptostegia, with the addition of the genus *Ellipsoidina*. It is represented for the most part by organisms of very rare occurrence, either in the recent or fossil condition, and until comparatively recently was supposed to comprise only a few fossil species of Cretaceous and Tertiary age.

The shelly skeleton of the Chilostomellidæ is invariably calcareous and perforate, and usually thin and transparent. The structural and morphological relations of the group are best understood by reference to the typical genus *Chilostomella*. This genus presents a uniaxial test, the chambers of which are put on alternately at the two ends, each segment almost completely enclosing the previous one, their point of attachment to each other being at one side of the shell. The aperture is at the margin of the last segment on its ventral side. In *Allomorphina* the segments alternate in ternary instead of binary series. As these two genera have still-living representatives, their characters will presently be noticed in greater detail.

In *Ellipsoidina* the arrangement is somewhat different. The chambers are elliptical and each larger than its predecessor, as in *Chilostomella;* but their point of attachment instead of being at one side, is at the base, and they are all projected symmetrically in one direction, instead of being directed alternately towards the two ends. The aperture is always at the distal extremity, and takes the form of an arcuate or nearly circular slit, either entire, or more commonly divided by shelly bridges. From the centre of the superior end of each segment, that is to say, either from the space enclosed by the curved aperture or its immediate neighbourhood, rises a shelly column of sufficient length to reach to the top of the succeeding chamber. This column is an anomalous feature, to which there is nothing precisely analogous amongst other Foraminifera. It was originally supposed to be a tubular neck serving for the aperture, and the genus was on that account

classed with the *Nodosarinæ;* but, as I have elsewhere shown,[1] this has not proved to be the fact, for the orifice occupies an independent position at its base, and the column itself is not hollow, but it is often deeply grooved longitudinally, or even split into two or three parts near the upper extremity. No example of the genus *Ellipsoidina* has hitherto been found in the recent condition; indeed it is known only by a single species, *Ellipsoidina ellipsoides*, Seguenza, the occurrence of which, so far as at present known, is confined to the Miocene formation of the neighbourhood of Messina.

Chilostomella, Reuss.

Chilostomella, Reuss [1849], Bornemann, Karrer, Hantken, Norman, Schwager, Brady, Siddall, Bütschli.

The genera *Chilostomella* and *Allomorphina* were established by Reuss on the basis of fossil specimens obtained from the Tertiary deposits of Austria and Germany, and were originally placed in d'Orbigny's Family, Enallostegia, between *Polymorphina* and *Textularia*. Subsequently, however, they were found to have so little in common with these, or indeed with any other known types of perforate Foraminifera, that in the later schemes of classification proposed by the same author they were removed from that position to form a distinct family.

Although the specimens included in the genus *Chilostomella* present considerable diversity of contour and vary also in some of their less important characters, there need be no hesitation in assigning them all to a single species; and the subjoined account of *Chilostomella ovoidea* serves equally as the description of the generic group.

Chilostomella ovoidea, Reuss (Pl. LV. figs. 12–23).

Chilostomella ovoidea, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 380, pl. xlviii. fig. 12, *a.–e.*
„ *czjzeki*, Id. Ibid., p. 380, pl. xlviii. fig. 13, *a.–d.*
„ *cylindroides*, Id. 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 80, pl. vi. fig. 43.
„ „ Bornemann, 1855, Ibid., vol. vii. p. 343, pl. xvii. fig. 1.
„ *tenuis*, Id. Ibid. p. 343, pl. xvii. fig. 2.
„ *oolina*, Schwager, 1878, Boll. R. Com. Geolog., Nos. 11, 12, p. 10, pl. i. fig. 16.
„ *ovoidea*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 66, pl. viii. figs. 11, 12.

The test of *Chilostomella ovoidea* is composed of a number of ovate or elliptical chambers, each a good deal larger than its predecessor; and each succeeding chamber encloses nearly the whole of the previous one, except a small portion at one end. The chambers are attached to each other at one side of the shell, and their direction of growth alternates, that is to say, they are put on first at one end and then at the other. The external line of union between the two visible segments is not directly transverse, but

[1] *Ann. and Mag. Nat. Hist.*, ser. 4, vol. i. p. 333 *et seq.*, pl. xiii.

dips towards the middle of the test on the dorsal side, so that more of the penultimate segment is exposed on that side than on the other. The aperture is a curved fissure, sometimes bordered by a thickened lip, and always situated on the ventral side, at the margin of the final segment. The shape of the test varies from an elongate or subcylindrical, to a short and rounded oval, between which extremes every gradational form may be met with; its texture is delicately thin and porous.

The series of drawings, Pl. LV. figs. 12–20, sufficiently indicates the variability of the species in point of external contour, as well as the diversity in the size and shape of the aperture. Figures 21 and 22 are thin-shelled specimens, mounted in Canada balsam and viewed by transmitted light, to show the arrangement of the chambers in the interior; and fig. 23 represents a shell with the outermost chamber broken, so as to expose the penultimate segment in its natural position.

It is somewhat remarkable that *Chilostomella ovoidea*, which is now known to be distributed over a very wide geographical area, and to be an exceedingly common species in many localities, should not have been found, or at any rate not have been recognised, as a recent Foraminifer, until six or seven years ago. It does not occur amongst the fossils of our native microzoic deposits, and before its discovery by the Rev. A. M. Norman in sands dredged off the south-west of Ireland, and amongst the material collected in the North Atlantic during the cruise of the "Valorous," the type was practically unknown to English Rhizopodists.

Mr. Norman informs me that the species is abundant on the coast of Norway, in the neighbourhood of Bergen, at depths of from 100 to 200 fathoms. It has been collected on the west coast of Ireland, 112 fathoms; in Vigo Bay, 11 fathoms; and at ten other localities in the North Atlantic, at depths ranging from 90 to 1350 fathoms. In the South Atlantic it is almost entirely wanting, having only been met with at a single point, just south of the equator, 2350 fathoms. The distribution-list further includes twelve Stations in the South Pacific, 150 to 1875 fathoms, and six in the North Pacific, 95 to 3125 fathoms.

The occurrence of *Chilostomella ovoidea* in the fossil condition appears to be confined to the Tertiary epoch. It has been found in the Septaria-clays of Hermsdorf, Freienwalde, Pietzpuhl, and Stettin, in North Germany (Reuss, Bornemann, Schlicht), in the *Clavulina-szabói* beds of Hungary (Hantken), in the Salt-clay of Wieliczka in Galicia (Reuss), in the Miocene of various localities in the neighbourhood of Vienna (Reuss, Karrer), and in the Miocene and Pliocene deposits of Calabria (Seguenza).

Allomorphina, Reuss.

Allomorphina, Reuss [1849], Karrer, Brady, Bütschli.

The genus *Allomorphina* differs from *Chilostomella* chiefly in the mode in which the segments are combined. The test, instead of being uniaxial, with the segments put on

alternately at either end, is more or less planospiral and subtriangular, portions of two segments in addition to the final one being visible externally. The final segment is relatively very large, and the aperture is a marginal slit on the line of union with the penultimate chamber.

This genus furnishes interesting isomorphs to certain arenaceous species; thus, for example, *Allomorphina trigona* bears a general resemblance in form and in the disposition of its chambers to many specimens of *Trochammina pauciloculata;* and *Allomorphina contraria* (Haidinger's Naturw. Abhandl., vol. iv. pl. v. fig. 7) presents a contour almost identical with that of *Trochammina galeata.*

Until comparatively recently *Allomorphina* was supposed to be an exclusively fossil type; but small specimens have been met with in the living condition in Challenger soundings from the Pacific. The genus makes its first appearance, geologically speaking, in the Cretaceous period, and is sparingly represented in various beds of Tertiary age in Central Europe.

Allomorphina trigona, Reuss (Pl. LV. figs. 24–26).

Allomorphina trigona, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 380, pl. xlviii. fig. 14, *a.–e.*
„ *cretacea*, Id. 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 42, pl. v. fig. 6.
„ *trigona*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 67, pl. viii. figs. 13, 14.

Of the two "species" above referred to, the former was described by Prof. Reuss from fossil examples of Miocene age, the latter from specimens of Cretaceous origin; but I am unable to recognise any morphological characters by which they can be distinguished from each other, and the day is long past for accepting difference of geological age as a ground of zoological distinction. Nor can I find in Tertiary specimens, kindly sent for comparison by my friend Dr. Karrer of Vienna, any feature by which they can be separated, even varietally, from those living at the present time. I have had no hesitation, therefore, in adopting for the recent specimens the name first employed for the species.

Allomorphina trigona is under all circumstances a rare Foraminifer. In the recent state it has only been found at two Challenger Stations, namely, the *Hyalonema*-ground to the south of Japan, depth 345 fathoms, and off Tahiti, Society Islands, 620 fathoms.

Its geological history may be gathered from Prof. Reuss's various memoirs. It occurs as a Cretaceous fossil in the Chalk-marl of Lemberg in Galicia; and has been observed in several formations of Tertiary age, such as the Septaria-clay of Eikel, near Salzgitter, the Salt-clay of Wieliczka, and various Miocene deposits of the neighbourhood of Vienna.

Family VII. LAGENIDÆ.

The Lagenidæ form an extensive family of vitreous Foraminifera, characterised primarily by the calcareous and finely perforated nature of the test, and its terminal aperture.

In the young condition the test is thin and transparent; but in mature specimens it is more commonly thickened by the continued deposit of calcareous shell-substance, either evenly over the whole surface, or in the form of exogenous growths, such as tubercles, spines, costæ, or reticulated lines.

The test is either monothalamous or polythalamous; when monothalamous it forms a simple chamber with a central orifice, when polythalamous it consists of a number of similar chambers or segments, joined one to the other in single series, usually in such a manner that the anterior wall of the first segment forms the posterior wall of the second, and so on.

The characters of the aperture vary in the several genera, but its typical aspect may be said to be that of a rounded orifice, either with an everted edge or divided at the margin by radiating fissures. In some genera—frequently in *Lagena* and *Nodosaria*, almost invariably in *Uvigerina*—the aperture is situated in a more or less extended tubular neck, terminating in a phialine lip.

The primitive or monothalamous condition of the test is exemplified in the genus *Lagena*, which consists typically of a single rounded or compressed chamber. A number of rounded *Lagena*-like chambers, joined end to end in a straight or curved line, form the test of the genus *Nodosaria*; and a straight test, similarly constructed, but of flattened segments compactly fitted together, that of *Lingulina*. *Frondicularia* exhibits similar features to the latter, but the shell is still more flattened, and the successive segments are embracing or equitant. The curved *Nodosariæ* with central aperture, pass by insensible gradations into the somewhat shorter forms with marginal orifice which compose the genus *Marginulina*; and these into the corresponding flattened varieties which constitute *Vaginulina*. In *Vaginulina* the test is more or less curved, and the segments are obliquely set: the increased obliquity of the early chambers leads to the production of the partially spiral test of the crosier-shaped modifications of *Cristellaria*, and these in turn to the typical or helicoid forms of that genus. There remain two other subordinate genera belonging to this series, namely, *Rhabdogonium*, the shell of which differs from that of the true *Nodosariæ* in its trilateral or quadrilateral contour and angular margins; and *Rimulina*, a subtype of *Vaginulina*, distinguished chiefly by the nature of its aperture.

In *Cristellaria* the convolutions are equilateral, and disposed in one plane; but there are other groups in which the chambers, though more or less spiral, are arranged round an elongated axis. Of these the genus *Polymorphina* comprises the less regular forms, and *Uvigerina* those which are more definitely spiral, the distinction between the two depending partly upon the characters of their respective apertures.

The genera which have been enumerated constitute an unbroken morphological series, with no lines of demarcation indicating the limits of the successive groups into which, for convenience, it has been divided; and the relationship between the various types of structure is strengthened and further complicated by the existence of intermediate forms, which present, in the same individual, the characters of two or more types. In this way *Nodosaria* is connected with *Frondicularia* by the dimorphous genus *Amphimorphina*, with *Rhabdogonium* by *Dentalinopsis*, with *Cristellaria* by *Amphicoryne*, with *Polymorphina* by *Dimorphina*, and with *Uvigerina* by *Sagrina;* and in like manner *Cristellaria* is associated with *Lingulina* by *Lingulinopsis*, and with *Frondicularia* by *Flabellina*.

Lastly, the genus *Ramulina*, which holds a position somewhat apart from the rest of the family, owing to its branching habit of growth, is nearly allied in all other respects to that section of the *Nodosariæ* in which the segments are separated by narrow stoloniferous tubes.

Sub-family 1. Lageninæ.

Lagena, Walker and Boys.

Orthoceras, pars, Soldani [1780].
Serpula (*Lagena*), Walker and Boys [1784], Adams, Kanmacher.
Vermiculum, pars, Montagu [1803].
Serpula, pars, Maton and Rackett [1807], Pennant, Turton.
Lagenula, Montfort [1808], Fleming, Macgillivray, Thorpe.
Amygdalites, Costa [1828].
Apiopterina, pars, Zborzewski [1834].
Miliola, pars, Ehrenberg [1839].
Oolina, d'Orbigny [1839], Reuss, Diesing, Czjzek, Costa, Egger, Terquem, Karrer, Kübler and Zwingli.
Cenchridium, Ehrenberg [1843].
Amphorina, d'Orbigny [1846 ?], Costa, Seguenza.
Lagena, Williamson [1848], Harvey and Bailey, Parker and Jones, Reuss, Gümbel, Carpenter, Stache, Brady, Karrer, Schwager, Hantken, Rymer Jones, &c.
Entosolenia (Ehrenberg, MS.), Williamson [1848], Parker and Jones, J. W. Dawson, Alcock, Whiteaves, G. M. Dawson, Fischer, Berthelin, Möbius.
Fissurina, Reuss [1849], Bornemann, Egger, Karrer, Seguenza, Schwager, Schlicht, Terquem, Marsson.
Ovulina, Ehrenberg [1854], Bornemann, Seguenza.
Amygdalina, Costa [1856], Seguenza.
Phialina, Costa [1856], Seguenza.
Holococcus? Ehrenberg [1859].
Trigonulina, *Tetragonulina*, *Obliquina*, Seguenza [1862].
Ovolina, Terquem [1866].
Lagenulina, Terquem [1876].
Capitellina, Marsson [1878].

In its essential features the genus *Lagena* presents the simplest and most elementary structure found in the hyaline series of Foraminifera. The test consists of a single

undivided chamber with a terminal aperture, or in exceptional cases with two apertures, and the walls are calcareous and finely perforated. These characters, simple as they appear, are compatible with an exceedingly wide range of variation in minor particulars, chiefly in relation to—(1) the shape of the test; (2) the nature of the aperture; and (3) the condition of the exterior with reference to surface-ornament.

The general contour of the shell may be subglobular or pyriform, as in *Lagena globosa*, ovate as in *Lagena ovum*, obovate as in *Lagena ovata*, truncate at the base as in

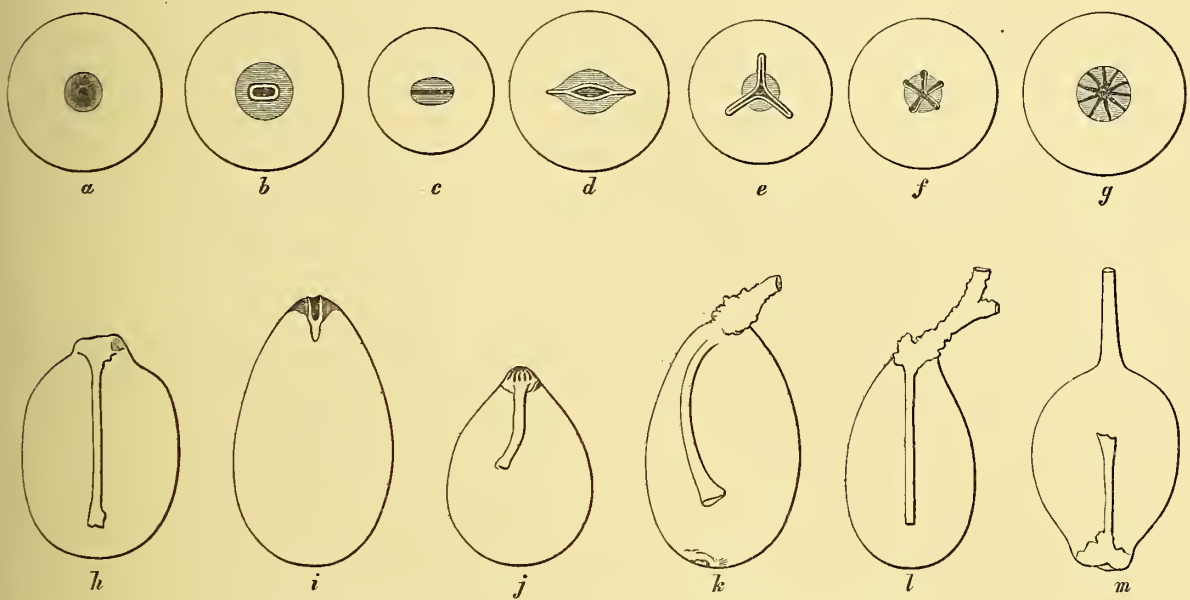

FIG. 11.—Various forms of aperture in *Lagena globosa*. Magnified 120 diameters.

a–g. Oral aspect of the shell, showing the external orifice.

a. Rounded orifice in a slight depression.
b. Oval orifice with raised border.
c. Simple elongated fissure.
d. Bordered fissure.
e. Triradiate fissure, with border.
f, *g*. Stellate orifices.

h–m. Lateral aspect of similar shells.

h. Specimen similar to *a*, showing the entosolenian tube.
i. Fissurine form like *d*, the internal tube hidden by the thickness of the shell.
j. Specimen with stellate orifice.
k, *l*. Entosolenian specimens with rough external necks, apparently of the same character as the fistular shelly growths of the *Polymorphinæ*.
m. Specimen with external (ectosolenian) neck at one end and internal tube at the other.

Lagena truncata, flask-shaped as in *Lagena lævis*, decanter-shaped as in *Lagena crenata*, cylindrical and curved as in *Lagena botelliformis*, fusiform as in *Lagena gracillima*, or elongate and tubular as in *Lagena elongata;* and many of these forms have corresponding flattened varieties, as well as others which are polygonal in outline, in addition to numerous modifications dependent to a greater or less degree upon supplementary or exogenous growths. The test is almost invariably equilateral, or in the polygonal varieties symmetrical; and this is so constant a rule that any irregularity of outline may be treated as the result of accident, or as due in some way to external conditions.

The aperture in its simplest form is a circular orifice or perforation at the anterior extremity of the shell, either opening directly into the rounded cavity or body of the test, or at the end of an extended tubular neck; but in a large section of the genus the neck is inverted and the external orifice opens into a tube which projects far into the interior of the shell; and in certain comparatively rare instances both the extended neck and the internal tube are present in the same specimen. These three conditions are known as the ectosolenian, entosolenian, and ecto-entosolenian varieties of aperture.

The external orifice, especially in the entosolenian varieties of *Lagena*, assumes very diverse characters, some idea of which, as well as of the form of the internal tube, may be gained from the annexed woodcuts (fig. 11). I am indebted to my friend Mr. Joseph Wright, F.G.S., of Belfast, for the specimens from which these outlines have been drawn. They were selected from material dredged within a limited area and at the same depth of water (Dublin Bay, 45 fathoms), and, so far as can be ascertained, under identical external conditions, yet they furnish examples of almost every form of mouth known amongst the vitreous types of Foraminifera.

The genus likewise presents a greater variety of surface-ornament than is met with in any other section of the same class of organisms. In a large number of forms the shell-wall is smooth externally, and though its substance is traversed by minute pseudopodial canals, they are as a rule invisible under ordinary magnifying powers, except in thin sections of the test. One or two species exhibit perforations which are of larger size and sometimes conspicuous externally, but these are exceptional. The decorated varieties have been roughly sorted according to the nature of the superficial ornament into three groups, namely—(1) *Asperæ*, (2) *Striatæ* or *Costatæ*, and (3) *Reticulatæ*. The first section comprises those forms in which the surface of the test is rugose, hispid, spinous, or beset with exogenous beads or tubercles; the second embraces those with striate, costate, alate, or fluted exterior; the third those in which the ornament consists of an arrangement of reticulated lines, whether regularly or irregularly disposed. Such a classification is of little real service to the systematist, for not unfrequently two or three sorts of decoration are found in a single specimen.

The elongated tubular neck is often ornamented quite independently of the body of the shell, the exogenous growths taking the form of raised annular or spiral bands, or of longitudinal wings or costæ. Ornament of this sort is not confined to particular species, but is found from time to time in many of the ectosolenian forms, and is also occasionally met with in the allied genus *Nodosaria*.

The arrangement of a group of organisms, the essential characters of which are so simple, and the minuter features so infinitely variable, is beset with difficulties. Two methods of subdivision have been suggested, both of them based upon the nature of the aperture. In that proposed by Williamson the genus is divided into *Lagenæ* proper, and *Entosoleniæ*, the distinction being based upon the absence or presence of an internal tube.

In the scheme proposed by Reuss the division is founded upon the character of the external orifice, the species having a simple rounded opening being assigned to *Lagena*, whilst those in which the aperture takes the shape of an elongated slit constitute a separate genus, *Fissurina*. From the narrow standpoint of a local fauna, where the number of anomalous examples appears relatively small, something may be said in favour of either of these methods of classification ; but they fail equally to be of service, and are on the other hand a source of additional complication, if any attempt be made to apply them to large collections or to specimens gathered from wider areas.

There are no doubt some forms of *Lagena* which are only known in the entosolenian condition, but in a majority of cases the same variety furnishes both ecto- and entosolenian specimens. Moebius (Foram. von Mauritius, p. 67) speaks of the entosolenian forms as representing a higher phase of organisation than the ectosolenian, on account of the internal tube ; but it may be pointed out that this peculiar feature is not confined to the *Lagenæ*, but is occasionally encountered in allied genera, notably in *Nodosaria* and *Polymorphina ;* and that it is amongst the poorly-developed modifications of the respective types, such as *Nodosaria calomorpha* and *Polymorphina angusta* and *Polymorphina lanceolata* that the entosolenian condition is most frequently observed.

Again the slit-like orifice, the essential character of Reuss's *Fissurinæ*, though a common peculiarity of the compressed varieties, is often replaced by a rounded opening which may or may not be situated at the middle of a long depression. But it is needless to pursue this subject ; enough has been stated already to make it clear that the characters of the aperture are altogether too inconstant to be employed even by way of specific distinction.

The sequence of forms throughout the genus is in fact too close and continuous and too much complicated by the overlapping of collateral varieties, to be capable of consistent or satisfactory arrangement of any sort. Parker and Jones treat all the known forms of *Lagena* as varieties and sub-varieties of a single species ; and from a strictly biological standpoint, this perhaps most nearly represents their true relationship. It is possible, however, to divide the generic series into sections, grouped round a few sub-typical forms, each section embracing a number of easily distinguished subordinate varieties, and many of these varieties in their turn including several minor modifications. An attempt has been made to indicate a graduated relationship of this sort in the annexed Synopsis, and though imperfect and lacking precision, the result may answer the purpose of a classification in the absence of anything better.

Scheme of the Genus LAGENA.

(The marginal numbers correspond to those in the Distribution Table.)

I. Typically, round in transverse section.

1	**Lagena globosa**, Walker & Jacob, sp. Typically, subglobular, entosolenian, and smooth externally, . . .	Pl. LVI.	figs. 1–3.
2	*apiculata*, Reuss, sp. Apiculate or mucronate forms of the same,	—	figs. 15–18.
3	*longispina*, Brady. Globular or somewhat compressed, with long basal spines, ...	—	figs. 33–36, &c
4	*L. ovum*, Ehrenberg, sp. Regularly elliptical, ...	—	fig. 5.
5	*L. ovata*, Terquem, sp. Obovate or trowel-shaped; broad and rounded at the apertural end, pointed at the base, . .		A.
6	*L. botelliformis*, Brady. Cylindrical, or elongate ovate, bent, . .	—	fig. 6.
7	**Lagena lævis**, Montagu, sp. Flask-shaped; with ectosolenian neck; smooth externally, ...	—	figs. 7–12, &c.
8	*L. clavata*, d'Orbigny, sp. Similar, but tapering to a point at the base,		B.
9	*L. gracillima*, Seguenza, sp. Attenuated, fusiform, often curved, generally distomous, ...	—	figs. 24–26, &c.
10	*L. elongata*, Ehrenb., sp. Attenuated, cylindrical, often distomous, .	—	fig. 29.
11	*L. truncata*, Brady. Truncate, and armed with a ring of peripheral spines at the base, ...	—	figs. 31, 32.
12	**Lagena aspera**, Reuss. Pyriform, surface decked with small, irregular, rounded or angular projections, . . .	Pl. LVII.	figs. 7–12.
13	*rudis*, Reuss. Surface rough with large and irregular projections, interspersed with dimples or depressions, . .		C.
14	*L. ampulla-distoma*, Ry. Jones. Subglobular, ecto-entosolenian; with roughened or areolated surface, especially near the base,	—	fig. 5.
15	*L. distoma-margaritifera*, Parker & Jones. Attenuated, fusiform, studded with beads or interrupted costæ; distomous,	Pl. LVIII.	fig. 16.
16	**Lagena hispida**, Reuss. Surface aculeate or spinous, . . .	Pl. LVII.	figs. 1–4.
17	*hystrix*, Reuss. Surface beset with tube-like truncated spines of unequal length, ...		D.
18	*L. distoma-aculeata*, P. & J. Elongate, fusiform, beset with prickles; distomous, ...		E.
19	**Lagena striata**, d'Orbigny, sp. Flask-shaped, surface ornamented with very numerous fine longitudinal striæ, . . .	—	figs. 22, 24, &c.
20	*lineata*, Williamson, sp. Ovate, mucronate, finely striate, entosolenian, ...	—	fig. 13.
21	*L. distoma*, P. & J. Elongate; cylindrical or slightly fusiform; with fine parallel striæ; distomous, . . .	Pl. LVIII.	figs. 11–15.
22	*L. curvilineata*, Balkwill & Wright. Surface ornamented with fine meandering striæ, ...		F.

23 *L. variata*, Brady. Often unsymmetrical or depressed; with irregular, depressed striæ, ... Pl. LXI. fig. 1.

24 **Lagena sulcata**, W. & J., sp. Surface ornamented with stout raised longitudinal costæ, ... Pl. LVII. figs. 23, 33, &c.

25 *interrupta*, Will. Costæ of unequal length, . . . — figs. 25, 27.

26 *acuticosta*, Reuss, with few, thin, much elevated costæ; sometimes irregularly placed, ... — figs. 31, 32.

27 *diversicostata*, Reuss. With few costæ, divided into two sets by a deep depression; the two central costæ continuous across the base of the test, ... G.

28 *williamsoni*, Alcock, sp. Pyriform, costate, with hexagonal ornament round the base of the neck, . . . H.

29 *L. gracilis*, Will. Elongate, fusiform, costate or striate; pointed at the inferior end; sometimes distomous, . . . Pl. LVIII. figs. 2, 3, 7, 8.

30 *L. alifera*, Reuss. Costæ very thin and high, taking the form of wings, I.

31 *L. quadralata*, Brady. Flask-shaped, finely striate; with four equidistant wings, ... Pl. LXI. fig. 3.

32 *L. plumigera*, Brady. Flask-shaped; with costæ developed at their lower ends into broad tubulated wings, . . Pl. LVIII. figs. 25–27.

33 **Lagena semistriata**, Williamson. Inferior portion of the test costate, superior portion smooth, ... Pl. LVII. figs. 14, 16, &c.

34 *tricostulata*, Marsson. Globular; with three parallel costæ reaching to the middle of the test, . . . J.

35 *multicosta*, Karrer, sp. Subglobular; aperture fissurine; with simple or bifurcating costæ reaching to the middle of the test, ... Pl. LXI. fig. 4.

36 *L. stelligera*, Brady. Pyriform; with short costæ proceeding from a raised rim or collar at the base, . . . Pl. LVII. figs. 35, 36.

37 *L. lebouriana*, Brady. Inferior end costate; the ribs connected by a transverse raised band encircling the test near the middle, ... K.

38 *L. gothica*, Ry. Jones. Lower half costate; the superior ends of the adjacent costæ curved over so as to form gothic arches, L.

39 *L. crenata*, P. & J. Decanter-shaped; the broad base ornamented with radiate crenulations proceeding from a small convex central disk, ... — fig. 21.

40 *L. exsculpta*, Brady. Ornament consisting of an excavated star, extending to near the middle of the test; radii fluted, bordered, round at the top, ... Pl. LVIII. fig. 1, &c.

41 **Lagena striatopunctata**, Parker & Jones. Multicostate; with conspicuous perforations at regular intervals on the costæ, . — figs. 37, 40.

42 *howchiniana*, Brady. Test crenulated or sub-costate; ridges perforated; wall of even thickness, . . . M.

43 *tetragona*, P. & J. Quadricostate, striato-punctate, . . N.

44 *spiralis*, Brady. Striato-punctate, costæ spiral, . . Pl. CXIV. fig. 9.

45	*L. desmophora*, Ry. Jones. Partially or entirely striato-punctate; the punctate costæ taking the form of chain-work,	Pl. LVIII.	figs. 42, 43.
46	*torquata*, Brady. Striato-punctate; the costæ connected by transverse bands; the alternate costæ looped or chain-like,	—	fig. 41.
47	*L. feildeniana*, Brady. Costate; the intercostal furrows punctured at regular intervals,	—	figs. 38, 39.
48	**Lagena hertwigiana**, Brady. Walls cellulated by the closing in and subdivision of the intercostal furrows	—	fig. 36.
49	**Lagena squamosa**, Montagu, sp. Pyriform; surface-ornament scale-like or irregularly reticulate,	—	figs. 28–31.
50	*L. melo*, d'Orbigny, sp. Pyriform; with surface-ornament of raised longitudinal bands connected by transverse bands of the same height,		O.
51	*L. hexagona*, Will., sp. Pyriform; with raised linear ornament arranged in regular hexagons,	—	figs. 32, 33.
52	*L. seminuda*, Brady. Hexagonal ornament extending only to the middle of the test,	—	fig. 34.
53	*L. favoso-punctata*, Brady. Surface-ornament a raised reticulation with a perforation in the centre of each areola,	—	fig. 35.
54	*L. tubifero-squamosa*, P. & J. Globular body with distinct ramifying neck, surface marked with shallow reticulations,		P.

II. Typically compressed on two or more sides.

55	**Lagena lævigata**, Reuss, sp. Shell nearly round in outline, compressed; margin obtusely angular,	Pl. CXIV.	fig. 8.
56	*L. lucida*, Will., sp. Pyriform, broad at the base, compressed,		Q.
57	*acuta*, Reuss, sp. Similar forms with apiculate base,		R.
58	*staphyllearia*, Schwager, sp. Base rounded; armed with regularly placed, short spines,	Pl. LIX.	figs. 8–11.
59	*unguiculata*, Brady. Base broad and thin, armed with a row of more or less curved teeth,	—	fig. 12.
60	*L. quadrata*, Will., sp. Subquadrate, compressed; sides nearly parallel, ends rounded,	—	figs. 3, 16.
61	*L. trigono-oblonga*, Seguenza, sp. Compressed on three sides, margins subangular,	Pl. LXI.	fig. 11.
62	*L. prima*, Seguenza, sp. Compressed on four sides, angles blunt,		S.
63	**Lagena marginata**, Walker & Boys, sp. Periphery bordered, carinate, or alate,	Pl. LIX.	figs. 21–23.
64	*semimarginata*, Reuss. Body biconvex, with long tubular neck and a wing on each side in the angle between the body and the neck, on the median line,	—	figs. 17, 19.
65	*dentata*, Seguenza, sp. Carina serrate or toothed,		T.
66	*L. siliqua*, Ry. Jones. Body circular, biconvex; surrounded by an elongate wing, tapering to a point at both ends,	—	fig. 27.

67 *L. seminiformis*, Schwager. Body circular, biconvex; with broad peripheral wing, extended at the base so as to form two points separated by a wide central depression, . Pl. LIX. figs. 28–30.

68 *tricuspidata*, Reuss, sp. Wing extended into three equidistant points, ... U.

69 *diptera*, Seguenza, sp. Wing broad; forming two wide-spreading pointed projections at the base, . . . V.

70 *L. lagenoides*, Will., sp. Body oval; with wide, conspicuously tubulated wing, ... Pl. LX. figs. 12–14, &c.

71 var. *tenuistriata*, Brady. Similar forms; the body ornamented with fine longitudinal striæ, ... — figs. 15, 16.

72 *L. ornata*, Will., sp. With cellulated wing, ... W.

73 *L. formosa*, Schwager. Body long, flask-shaped, compressed; with tubulated wing, emarginate at the base, and with a raised border immediately surrounding the body, on both sides of the shell, ... — figs. 18–20.

74 var. *favosa*, Brady. Similar form with reticulated border within the wing, ... — fig. 21.

75 var. *comata*, Brady. Similar form, the body delicately striate, . — fig. 22.

76 var. *brevis*, Brady. Short form, with punctate surface, the intermediate border transversely ribbed, . . . Pl. CXIV. fig. 10.

77 *L. squamoso-marginata*, P. & J. Flasked-shaped, compressed; margin acute; surface squamose or areolated, . . . Pl. LX. fig. 24.

78 *L. squamoso-alata*, Brady. Margin furnished with a tubulated wing, surface areolated, ... — fig. 23.

79 *L. radiato-marginata*, P. & J. Compressed, bordered; lateral surfaces marked with lines radiating from the centre . . Pl. LXI. figs. 8, 9.

80 *L. wrightiana*, Brady. Convex faces ornamented with parallel, longitudinal grooves, except near the centre, . . — figs. 6, 7.

81 *L. schulzeana*, Brady. Faces ornamented with transverse bars, horizontal at the middle and bent downwards near the periphery, — fig. 10.

82 *L. capillosa*, Schwager, sp. Carinate; carina partially divided on the median line, ... X.

83 *L. trigono-marginata*, P. & J. Compressed on three sides, angles acute, bordered, ... — figs. 12, 13.

84 *L. trigono-ornata*, Brady. Compressed on three sides, angles decked with honey-combed ornament, . . . — fig. 14.

85 *L. quadrangularis*, Brady. Flattened; quadrangular in section, the angles subcarinate, ... Pl. CXIV. fig. 11.

86 *L. quinquelatera*, Brady. Flask-shaped, compressed on five sides, equilateral, angles acute or subcarinate, . . Pl. LXI. figs. 15, 16.

87 **Lagena orbignyana**, Seguenza, sp. With three parallel carinæ; the central one widest, ... Pl. LIX. figs. 24–26.

88 *bicarinata*, Terquem, sp. With double margin and depressed median line, ... Y.

89	*L. castrensis*, Schwager. Tricarinate; convex faces ornamented with raised beads, ...	Pl. LX.	figs. 1, 2.
90	*L. clathrata*, Brady. Tricarinate; convex faces ornamented with longitudinal parallel costæ, ...	—	fig. 4.
91	*L. pulchella*, Brady. Tricarinate; convex faces ornamented with irregular, longitudinal, branching costæ, . .		Z.
92	*L. quadricostulata*, Reuss, Test pyriform, compressed; with two curved longitudinal costæ on each face, near the margin, .	Pl. LIX.	fig. 15.
93	*L. clypeato-marginata*, Ry. Jones. Body flask-shaped; with broad median wing encircling the whole, dividing into three wings at the base, ...		AA.
94	*L. fimbriata*, Brady. Pyriform, compressed; with deep, tubulated, sometimes fringed, vertical wing surrounding the oval base, ...	Pl. LX.	figs. 26–28.
95	*L. auriculata*, Brady. Pyriform, compressed; bearing on each side near the base, a loop-like wing enclosing a portion of the peripheral margin, ...	—	figs. 29, 33.
96	var. *costata*, Brady. The same with costate ornament, . .	—	fig. 38.
97	*L. alveolata*, Brady. Pyriform, compressed; with central and two lateral carinæ at the base, cut away at the middle and uniting so as to form two loops on each side of the test, ...	—	figs. 30, 32.
98	var. *caudigera*, Brady. Similar, but armed with two long basal spines and a central mucro, ...	—	fig. 25.
99	var. *substriata*, Brady. Similar in form, the surface partially striate.	—	fig. 34.

References to descriptions and figures of the species not illustrated in the plates.

A. *Oolina ovata*, Terquem, 1858, Foram. du Lias, 1ière Mém., p. 586, pl. i. fig. 2;—Blake, 1876, Yorkshire Lias, p. 454, pl. xviii. fig. 10.

B. *Oolina clavata*, d'Orbigny, 1846, For. Foss. Vien., p. 24, pl. i. figs. 2, 3.

C. *Lagena rudis*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 336, pl. vi. fig. 82.

D. *Lagena hystrix*, Id. Ibid. p. 335, pl. vi. fig. 80.

E. *Lagena distoma-aculeata*, Parker & Jones, 1865, Phil. Trans., vol. clv. p. 348, pl. xviii. fig. 5.

F. *Lagena curvilineata*, Balkwill & Wright, 1882, Proc. R. Irish Acad., ser. 2, vol. iii. (Science) p. 548, [name only].

G. *Lagena diversicostata*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol xlvi. p. 331, pl. v. fig. 64.

H. *Entosolenia williamsoni*, Alcock, 1865, Proc. Lit. and Phil. Soc. Manchester, vol. iv. p. 193. Figured by Wright, Proc. Belfast Nat. Field Club, 1876–77, App., pl. iv. fig. 14.

I. *Lagena alifera*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 467, No. 11;—Schlicht, 1870, Foram. Pietzpuhl, pl. iii. figs. 15, 16, 21, 22.

J. *Lagena tricostulata*, Marsson, 1878, Mittheil. naturw. Vereine Neu-Vorpom. u. Rügen, Jahrg. x. p. 122, pl. i. fig. 2.

K. *Lagena lebouriana*, Brady, 1876, Monogr. Carb. and Perm. Foram., p. 121, pl. viii. fig. 6.

L. *Lagena vulgaris*, var. *gothica*, Rymer Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 51, pl. xix. fig. 9.

M. *Lagena howchiniana*, Brady, 1876, Monogr. Carb. and Perm. Foram., p. 121, pl. x. figs. 1–5.

N. *Lagena tetragona*, Parker & Jones, 1865, Phil. Trans., vol. clv. p. 420, pl. xviii. fig. 14, *a.b.*

O. *Oolina melo*, d'Orbigny, 1839, Foram. Amér. Mérid., p. 20, pl. v. fig. 9.

P. *Lagena tubifero-squamosa*, Parker & Jones, 1865, Phil. Trans., vol. clv. p. 420, pl. xviii. fig. 7, *a.b.*

Q. *Entosolenia marginata*, var. *lucida*, Williamson, 1858, Rec. For. Gt. Br., p. 10, pl. i. figs. 22, 23.

R. *Fissurina acuta*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 340, pl. vii. figs. 90, 91. (The specimen figured, Pl. LIX. fig. 6, though probably belonging to this variety, is not typical).

S. *Tetragonulina prima*, Seguenza, 1862, Foram. Monotal. Mess., pl. ii. figs. 54, 55.

T. *Fissurina dentata*, Id. Ibid. p. 58, pl. i. fig. 55.

U. *Fissurina tricuspidata*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 470, No. 3;—Schlicht, 1870, Foram. Pietzpuhl, pl. v. figs. 16–18.

V. *Fissurina diptera*, Seguenza, 1879, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 332, pl. xvii. fig. 36.

W. *Entosolenia marginata*, var. *ornata*, Williamson, 1858, Rec. For. Gt. Br., p. 11, pl. i. fig. 24.

X. *Fissurina capillosa*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 210, pl. v. fig. 25.

Y. *Fissurina bicarinata*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III. p. 31, pl. i. fig. 24, *a.b.*

Z. *Lagena pulchella*, Brady, 1870, Ann. and Mag. Nat. Hist., ser. 4, vol. vi. p. 294, pl. xii. fig. 1, *a.b.*

AA. *Lagena vulgaris*, var. *clypeato-marginata*, Rymer Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 58, pl. xix. fig. 37.

The geographical distribution of the genus is subject to no restrictions either of latitude or depth of water. It is to all appearance equally at home in the Arctic Ocean, at the Equator, and at the Antarctic Ice-barrier. It is common in littoral sands between tide-marks and in estuarine shallows, and at every intermediate depth to the abysses of mid-ocean at 3000 fathoms or more.

Its geological distribution is on a corresponding scale. Characteristic specimens of two species have been discovered by Mr. John Smith of Kilwinning, in the Upper Silurian shales of Staffordshire and Herefordshire, and at least three forms are known to have existed during the Carboniferous epoch. From the Trias only one, and that a somewhat doubtful variety, has been recorded,[1] but from the Liassic and Oolitic formations the number of forms is considerable, and the rocks of the Cretaceous period have furnished not less than thirteen well-marked species or varieties. In early Tertiary times there was again a great accession of species, and in the later formations the genus became one of the most abundant of all the Foraminiferal types.

[1] *Lagena polygona* (?) Reuss, *Sitzungsb. d. k. Ak. Wiss. Wien*, vol. lvii. p. 107, pl. i. fig. 11, from the Trias of St. Cassian.

TABLE SHOWING THE GEOLOGICAL DISTRIBUTION OF THE PRINCIPAL FORMS OF LAGENA.

		Upper Silurian.	Carboniferous.	Lias.	Oolite.	Cretaceous.	Eocene.	Oligocene.	Miocene.	Pliocene.	Pleistocene.	Living.	
1	*Lagena globosa* (W. & J.),				×	×	×	×	×	×	×	×	1
2	„ *apiculata*, Reuss,			×	×	×	×	×	×	×	×	×	2
3	„ *longispina*, Brady,											×	3
4	„ *ovum* (Ehr.),					×	×					×	4
5	„ *ovata* (Terquem),			×									5
6	„ *botelliformis*, Brady,											×	6
7	„ *lævis* (Mont.),	×	?	×	×	×	×	×	×	×	×	×	7
8	„ *clavata* (d'Orb.),			×	×		×		×	×	×	×	8
9	„ *gracillima* (Seg.),								×	×	×	×	9
10	„ *elongata* (Ehr.),			×		×						×	10
11	„ *truncata*, Brady,											×	11
12	„ *aspera*, Reuss,		×	×	×	×					×	×	12
13	„ *rudis*, Reuss,									×			13
14	„ *ampulla-distoma*, Ry. J.,											×	14
15	„ *distoma-margaritifera*, P. & J.,						×					×	15
16	„ *hispida*, Reuss,			×			×	×	×	×	×	×	16
17	„ *hystrix*, Reuss,					×	×	×					17
18	„ *distoma-aculeata*, P. & J.,						×						18
19	„ *striata* (d'Orb.),							×	×	×	×	×	19
20	„ *lineata* (Will.),										×	×	20
21	„ *distoma*, P. & J.,									×	×	×	21
22	„ *curvilineata*, B. & W.,											×	22
23	„ *variata*, Brady,											×	23
24	„ *sulcata* (W. & J.),	×		×		×	×	×	×	×	×	×	24
25	„ *interrupta*, Will.,						×			×	×	×	25
26	„ *acuticosta*, Reuss,					×		×				×	26
27	„ *diversicostata*, Reuss,								×				27
28	„ *williamsoni*, Alcock,										×	×	28
29	„ *gracilis*, Will.,					×		×		×	×	×	29
30	„ *alifera*, Reuss,							×					30
31	„ *quadralata*, Brady,											×	31
32	„ *plumigera*, Brady,											×	32
33	„ *semistriata*, Will.,						×	×		×	×	×	33
34	„ *tricostulata*, Marss.,					×							34
35	„ *multicostata* (Karrer),								×			×	35
36	„ *stelligera*, Brady,											×	36
37	„ *lebouriana*, Brady,		×										37
38	„ *gothica*, Ry. J.,											×	38

		Upper Silurian.	Carboniferous.	Lias.	Oolite.	Cretaceous.	Eocene.	Oligocene.	Miocene.	Pliocene.	Pleistocene	Living.	
39	*Lagena crenata*, P. & J.,								×		×	×	39
40	„ *exsculpta*, Brady,						×					×	40
41	„ *striatopunctata*, P. & J.,							×			×	×	41
42	„ *howchiniana*, Brady,		×										42
43	„ *tetragona*, P. & J.,						×						43
44	„ *spiralis*, Brady,											×	44
45	„ *desmophora*, Ry. J.,											×	45
46	„ *torquata*, Brady,											×	46
47	„ *feildeniana*, Brady,											×	47
48	„ *hertwigiana*, Brady,											×	48
49	„ *squamosa* (Mont.),						×		×	×	×	×	49
50	„ *melo* (d'Orb.),								×	×	×	×	50
51	„ *hexagona* (Will.),							×	×	×	×	×	51
52	„ *seminuda*, Brady,											×	52
53	„ *favoso-punctata*, Brady,											×	53
54	„ *tubifero-squamosa*, P. & J.,						×						54
55	„ *lævigata* (Reuss),					×	×	×	×	×	×	×	55
56	„ *lucida* (Will.),								×	×	×	×	56
57	„ *acuta* (Reuss),							×	×	×		×	57
58	„ *staphyllearia* (Schwager),									×		×	58
59	„ *unguiculata*, Brady,											×	59
60	„ *quadrata* (Will.),								×	×	×	×	60
61	„ *trigono-oblonga* (Seg.),								×		×	×	61
62	„ *prima* (Seg.),								×				62
63	„ *marginata* (W. & B.),					×	×	×	×	×	×	×	63
64	„ *semimarginata*, Reuss,							×				×	64
65	„ *dentata* (Seg.),								×			×	65
66	„ *siliqua*, Ry. J.											×	66
67	„ *seminiformis*, Schwager,					?				×		×	67
68	„ *tricuspidata* (Reuss),								×				68
69	„ *diptera* (Seg.),									×			69
70	„ *lagenoides* (Will.),								×	×	×	×	70
71	„ v. *tenuistriata*, Brady,										×	×	71
72	„ *ornata* (Will.),									×	×	×	72
73	„ *formosa*, Schwager,									×		×	73
74	„ v. *favosa*, Brady,											×	74
75	„ v. *comata*, Brady,											×	75
76	„ v. *brevis*, Brady,											×	76
77	„ *squamoso-marginata*, P. & J.,								×	×		×	77
78	„ *squamoso-alata*, Brady,											×	78
79	„ *radiato-marginata*, P. & J.,								×			×	79

		Upper Silurian.	Carboniferous.	Lias.	Oolite.	Cretaceous.	Eocene.	Oligocene.	Miocene.	Pliocene.	Pleistocene.	Living.	
80	*Lagena wrightiana*, Brady, . . .											×	80
81	„ *schulzeana*, Brady, . . .											×	81
82	„ *capillosa* (Schwager), . .									×			82
83	„ *trigono-marginata*, P. & J., .			×			×				×	×	83
84	„ *trigono-ornata*, Brady, . .										×	×	84
85	„ *quadrangularis*, Brady, . .											×	85
86	„ *quinquelatera*, Brady, . .											×	86
87	„ *orbignyana* (Seg.), . . .						×	×	×		×	×	87
88	„ *bicarinata* (Terquem), . .						×					×	88
89	„ *castrensis*, Schwager, . .									×		×	89
90	„ *clathrata*, Brady, . . .											×	90
91	„ *pulchella*, Brady, . . .										×	×	91
92	„ *quadricostulata*, Reuss, . .							×				×	92
93	„ *clypeato-marginata*, Ry. J., .											×	93
94	„ *fimbriata*, Brady, . . .											×	94
95	„ *auriculata*, Brady, . . .											×	95
96	„ v. *costata*, Brady, . . .											×	96
97	„ *alveolata*, Brady, . . .											×	97
98	„ v. *caudigera*, Brady, . . .											×	98
99	„ v. *substriata*, Brady, . . .											×	99

Lagena globosa, Montagu, sp. (Pl. LVI. figs. 1, 2, 3).

"Serpula (Lagena) lævis globosa," Walker and Boys, 1784, Test Min., p. 3, pl. i. fig. 8.
"Ossicula *madreporaria*," Soldani, 1795, Testaceographia, vol. i. pt. 3, p. 245, pl. clxxii., figs. B. C., &c.
Vermiculum globosum, Montagu, 1803, Test. Brit., p. 523.
Oolina inornata, d'Orbigny, 1839, Foram. Amér. Mérid., p. 21, pl. v. fig. 13.
„ *simplex*, Reuss, 1851, Haidinger's Naturw. Abhandl., vol. iv. p. 22, pl. i. fig. 2.
Miliola sphæroidea, Ehrenberg, 1854, Mikrogeologie, pl. xxiii. fig. 1.
Cenchridium oliva, Id. Ibid. pl. xxiv. figs. 3, 4.
Phialina oviformis, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 123, pl. xi. figs. 8, 9.
Fissurina obtusa, Egger, 1857, Neues Jahrb. für Min., &c., p. 270, pl. v. figs. 16–19.
Entosolenia globosa, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 278, pl. xi. figs. 25–29.
„ „ Williamson, 1858, Rec. For. Gt. Br., p. 8, pl. i. figs. 15, 16.
Fissurina solida, Seguenza, 1862, Foram. Monotal. Mess., p. 56, pl. i. fig. 42.
„ *rugosula*, Id. Ibid. p. 56, pl. i. fig. 43.
Lagena globosa, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 318, pl. i. figs. 1–3.

Lagena sulcata, var. (*Entosolenia*) *globosa*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 348, pl. xiii. fig. 37; pl. xvi. fig. 10.
Cenchridium aargovense, Kübler, 1870, Foram. schweiz. Jura, p. 13, pl. ii. I. fig. 2.
Lagena parkinsoni, Id. Ibid. p. 17, pl. ii. III. fig. 1.
„ *minutissima*, Id. Ibid. pp. 19, 21, pl. ii. IV. fig. 1.
Lagenulina globosa, Terquem, 1876, Anim. sur la Plage de Dunkerque, fasc. 2, p. 67, pl. vii. figs. 3, 4.

The test of *Lagena globosa* is subglobular, pyriform, or elliptical, and the aperture is situated in an entosolenian neck. The wonderfully diversified characters of the external orifice have already been adverted to (*ante*, p. 441). The surface of the shell is invariably smooth.

In the living condition *Lagena globosa* is a cosmopolitan species, frequenting every latitude and almost every depth of water at which calcareous Foraminifera have been found.

Whether its geological distribution extends to older horizons than the Oolite cannot be stated with certainty. Specimens similar in general contour, but more or less rugose externally, have been met with in Carboniferous Limestone shales, and these, pending further research, have been assigned to *Lagena aspera*; but from the Jurassic age to the Post-tertiary, the typical form is a constituent of almost every marine fossiliferous deposit.

Lagena apiculata, Reuss (Pl. LVI. figs. 4, 15–18).

Oolina apiculata, Reuss, 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 22, pl. i. fig. 1.
Miliola caudata, Ehrenberg, 1854, Mikrogeologie, pl. xxix. fig. 46.
Lagena apiculata, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 319, pl. i. figs. 4–8, 10, 11.
Ovulina caudigera, Seguenza, 1862, Foram. Monotal. Mess., p. 39, pl. i. fig. 3.
„ *perforata*, Id. Ibid. p. 40, pl. i. fig. 4.
Lagena sulcata, var. (*Entosolenia*) *apiculata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 358.
„ „ „ *caudata*, Id. Ibid.
„ *apiculata*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 44, pl. i. fig. 27.

Lagena apiculata is an entosolenian variety, only differing from *Lagena globosa* in having a pointed instead of a rounded base.

Like the allied form it is cosmopolitan, and has been found at every depth from the littoral zone down to 2750 fathoms.

It is also one of the commonest of fossil *Lagenæ*, occurring in microzoic rocks of almost every age as far back as the Lias.

Lagena longispina, H. B. Brady (globular form Pl. LVI. figs. 33, 36; compressed specimens, Pl. LIX. figs. 13, 14).

Lagena longispina, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

Test entosolenian; subglobular or pyriform, sometimes compressed; furnished with a number of long basal spines; surface smooth. Length of the body, $\frac{1}{25}$th inch (1 mm.), or less.

This again is only a variety of *Lagena globosa*, the shell of which is armed at the base with a number of spines, either irregularly placed or, in the compressed forms, springing from near the median line. Sometimes the spines attain large dimensions, and specimens have been found in which they measure nearly twice the length of the body of the test.

Spinous *Lagenæ* of this description are found sparingly in deep water all over the world. They have been met with at about a dozen Challenger Stations in areas wide apart, at depths ranging from 1070 to 2740 fathoms.

Lagena ovum, Ehrenberg, sp. (Pl. LVI. fig. 5).

Miliola ovum, Ehrenberg, 1843, Berlin Monatsb., p. 166;—1854, Mikrogeologie, pl. xxiii. fig. 2; pl. xxix. fig. 45; pl. xxxi. fig. 4.
Lagena perovalis, Gümbel, 1868, Abh. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 606, pl. i. fig. 7.
„ *globosa*, var. *ovalis*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 466, No. 1, α;—Schlicht, 1870, Foram. Pietzpuhl., pl. i. figs. 6, 7.
„ *ovum*, Marsson, 1878, Mittheil. naturw. Vereine v. Neu-Vorpom. u. Rügen, Jahrg. x. p. 120, pl. i. fig. 1.

Ehrenberg's designation may be accepted for the symmetrically elliptical varieties of *Lagena globosa*, of which Pl. LVI. fig. 5 presents a typical example.

Lagena ovum is not common as a living organism, though it is occasionally met with amongst other minute thin-shelled varieties of the genus. The figured specimen is from the deep area of the North Pacific, 2300 fathoms.

It occurs in the Lower Lias of Yorkshire (Tate), in the Chalk of the Islands of Moën and Rügen (Ehrenberg, Marsson), in the Eocene Limestones of Egypt and of the Bavarian Alps (Ehrenberg, Gümbel), and in the Septaria-clay of Pietzpuhl (Schlicht).

Lagena botelliformis, H. B. Brady (Pl. LVI. fig. 6).

Lagena botelliformis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 60.

Test entosolenian; long, cylindrical, of even diameter, arcuate; ends rounded; surface smooth. Length about $\frac{1}{50}$th inch (0·5 mm.).

This is an elongate arched variety, occasionally met with in company with *Lagena globosa* and *Lagena lævis*, though by no means common.

The figured specimen was dredged in shallow water off the Cape de Verde Islands; others occur in material from mid-ocean in the South Atlantic, 2350 fathoms, and from Station 302, south of Juan Fernandez, 1450 fathoms.

Lagena lævis, Montagu, sp. (Pl. LVI. figs. 7–14, 30).

"Serpula (Lagena) lævis ovalis," Walker and Boys, 1784, Test. Min., p. 3, pl. i. fig. 9.
"Testæ oviformes, glandiformes, fusiformes," &c., Soldani, 1798, Testaceographia, vol. ii. pp. 16, 17, pl. iii. fig. *ee. ll. rr.*; pl. iv. fig. *ss.*
Vermiculum læve, Montagu, 1803, Test. Brit., p. 524.
Lagenula lævis, Fleming, 1828, Brit. Anim., p. 235.
Lagena lævis, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 12, pl. i. figs. 1, 2.
Miliola lævis, Ehrenberg, 1854, Mikrogeologie, pl. xxvi. fig. 2; pl. xxxi. fig. 5.
Ovulina clava, Id. Ibid. pl. xxxii. II. fig. 2, *b*.
Phialina pyriformis, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 123, pl. xi. figs. 6, 10.
Lagena vulgaris, Williamson, 1858, Rec. For. Gt. Br., p. 4, pl. i. figs. 5, 5*a*.
Phialina propinqua, Seguenza, 1862, Foram. Monotal. Mess., p. 43, pl. i. fig. 13.
,, *ovata*, Id. Ibid. p. 44, pl. i. fig. 14.
,, *longirostris*, Id. Ibid. p. 44, pl. i. fig. 15.
,, *affinis*, Id. Ibid. p. 44, pl. i. fig. 16.
,, *clavata*, Id. Ibid. p. 45, pl. i. fig. 17.
Lagena vulgaris, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 321, pl. i. fig. 15; pl. ii. figs. 16, 17.
,, *sulcata*, var. *lævis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 349, pl. xiii. fig. 22; pl. xvi. fig. 9*a*.
,, *lævis*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 33, pl. i. fig. 28.
,, *helvetica*, Kübler, 1870, Foram. schweiz. Jura, pp. 24, 33, pl. iii. fig. 1; pl. iv. I. fig. 1.
,, *badenensis*, Id. Ibid. p. 38, pl. iv. VI. fig. 1.
,, *lævis*, Blake, 1876, Yorkshire Lias, p. 453, pl. xviii. figs. 7, 7*a*.

Lagena lævis represents almost the simplest type of hyaline Foraminifera. The test consists of a globular, oval, pyriform, or subfusiform chamber, with a produced tubular neck. In the typical condition it is quite smooth externally, and its range of morphological variation is confined to mere differences of outline. Specimens from very deep water are often opaque, and sometimes have a slightly roughened surface.

It is perhaps the commonest and most widely distributed of all the *Lagenæ*, and may be found living in every sea, from the Arctic Ocean, within about ten degrees of the North Pole, to the Antarctic Ice-barrier, lat. 64° 18′ S.; and at every depth, from the shore-pools of the coast-line down to 2435 fathoms.

It makes its earliest appearance during the Upper Silurian age,—in the Wenlock Limestone shales of Sedgley, and in similar rocks at Lincoln Hill, Woolhope (Smith). Its presence in the Carboniferous rocks is doubtful; but it has been found in the Lower Lias of

Yorkshire (Blake), in the Middle Lias of Essey-les-Nancy, France (Terquem and Berthelin), in the Oolite of Switzerland and France, and thenceforward in marine deposits of almost every period down to recent times.

Lagena clavata, d'Orbigny, sp.

Oolina clavata, d'Orbigny, 1846, For. Foss. Vien., p. 24, pl. i. figs. 2, 3.

A modification of *Lagena lævis*, distinguished by the fusiform contour of the body of the shell and its pointed base. A figure of this variety has been accidentally omitted from the plates.

The distribution of *Lagena clavata*, whether geographical or geological, is probably nearly coextensive with that of *Lagena lævis*, though in point of number the specimens are much less abundant than those of the type.

Lagena gracillima, Seguenza, sp. (Pl. LVI. figs. 19–28).

"Testæ *Ovales, fusiformes*," &c., Soldani, 1798, Testaceographia, vol. ii. p. 37, pl. xii. fig. Q.
Miliola lævis (pars), Ehrenberg, 1845, Mikrogeologie, pl. xxvi. fig. 2.
Amphorina gracilis, Costa, 1856, Atti dell' Accad. Pont., p. 121, pl. xi. fig. 11.
„ *gracillima*, Seguenza, 1862, Foram. Monotal. Mess., p. 51, pl. i. fig. 37.
„ *acuminata*, Id. Ibid. p. 51, pl. i. fig. 35.
„ *cylindracea*, Id. Ibid. p. 51, pl. i. fig. 36.
„ *distorta*, Id. Ibid. p. 52, pl. i. fig. 38.
Lagena sulcata, var. *distoma-polita*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 357, pl. xiii. fig. 21; pl. xviii. fig. 8.
„ *gracillima*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 45, pl. i. figs. 36, 37.

The test of *Lagena gracillima* is long and slender, broadest near the middle, and drawn out to a fine point at the extremities, each of which carries an aperture. Seguenza's name, under which the variety is generally known, has been retained, as the antecedent term "*gracilis*," employed by Costa, has become associated with a somewhat different form.

In the living condition *Lagena gracillima* is a very common Foraminifer, occurring in almost every latitude, and at depths ranging from estuarine shallows to the mid-ocean bed at 2300 fathoms.

It is found as a fossil in the Miocene and Pliocene of Sicily and Southern Italy (Seguenza), in the Crag of the east of England (Jones, Parker, and Brady); and in the Post-tertiary deposits of Norway (Crosskey and Robertson), of the west of Scotland (Robertson), and of the north-east of Ireland (Wright).

Lagena elongata, Ehrenberg, sp. (Pl. LVI. fig. 29).

Miliola elongata, Ehrenberg, 1854, Mikrogeologie, pl. xxv. fig. 1.
Oolina lanceolata, Terquem, 1858, Foram. du Lias, 1ière. Mém., p. 586.
„ *acicularis*, Id. Ibid. p. 586, pl. i. fig. 2.
„ *virgula*, Id. 1862, Ibid. 2ième. Mém., p. 431, woodcut.
„ *lagenalis*, Id. Ibid. p. 429, pl. v. fig. 1.
„ *simplex*, Id. Ibid. p. 430, pl. v. fig. 2.
„ *fusiformis*, Id. 1863, Ibid. 3ième. Mém., p. 167, pl. vii. fig. 1.
Lagena elongata, Blake, 1876, Yorkshire Lias, p. 454, pl. xviii. figs. 9, 9*a*.

This variety has been admitted in the sense in which it is recognised by Blake, namely, for cylindrical distomous forms, of nearly even diameter, except near the ends, which are contracted or slightly tapering. It is only distinguished from *Lagena gracillima* by a trifling difference of contour. The synonymy is quoted from the same authority. Many of Terquem's figures are exceedingly ill-defined, and it may be questioned whether some of them represent *Lagenæ* at all.

Lagena elongata has been found in company with *Lagena gracillima* at four Challenger Stations, in the North Atlantic and South Pacific, at depths of 28 to 1070 fathoms.

It occurs as a fossil in the Lias of England (Blake), and of France (Terquem), and in the Cretaceous limestones of the Antilibanon (Ehrenberg).

Lagena truncata, n. sp. (Pl. LVI. figs. 31, 32).

Test elongate, pyriform, entosolenian; broadest below the middle; superior portion tapering, oral extremity rounded or obtusely pointed; inferior end truncate and armed with two or more short peripheral spines. Aperture either round or fissurine. Length, $\frac{1}{60}$th inch (0·4 mm.).

Entosolenian *Lagenæ* with truncate and spinous base, answering to the foregoing description, have been encountered at the following localities:—North Atlantic, south-west of the Canaries, 2740 fathoms; South Atlantic, west of Tristan d'Acunha, 2200 fathoms; and at two points in the South Pacific, 2070 fathoms and 1825 fathoms respectively.

Lagena aspera, Reuss (Pl. LVII. figs. 7–10; varieties, figs. 6, 11, 12).

Lagena aspera, Reuss, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 305, pl. i. fig. 5.
„ „ Id. 1863, Ibid. vol. xlvi. p. 335, pl. vi. fig. 81.
„ *parkeriana*, (?) Brady, 1876, Monogr. Carb. and Perm. Foram., p. 120, pl. viii. figs. 1–5.
„ *aspera*, Siddall, 1878, Proc. Chester. Soc. Nat. Sci., pt. 2, p. 48.

The test of *Lagena aspera*, as originally figured by Reuss from a Tertiary specimen, resembles that of *Lagena globosa* in contour,—that is to say, it is subglobular or

pyriform, and entosolenian—and the surface is beset with minute, rounded, exogenous beads, distributed without apparent order.

Similar specimens are occasionally met with in the living condition, but the finer examples, from deep water, are almost invariably ectosolenian, and possess a short wide external neck, as in figs. 8–11. In rare instances the bead-like ornament assumes more or less regular lines, as shown in fig. 11. Figure 12 represents a somewhat anomalous shell, of compressed and inequilateral contour, and with both ento- and ecto-solenian apertures, the surface-ornament preserving the same general character as the rest.

Assuming that the rough or sometimes apparently tuberculate surface of the Palæozoic form, *Lagena parkeriana*, is the natural condition of the test, and not brought about by age or by the nature of the matrix in which the specimens have so long lain embedded, there seems no reason why it should be kept distinct from the present species.

Lagena aspera has been noticed at two Stations in the South Atlantic, at depths of 675 fathoms and 1900 fathoms; at four in the South Pacific, 155 to 1375 fathoms; and at two in the North Pacific, 2050 fathoms and 2300 fathoms respectively. It has also been found in comparatively shallow water in the British seas.

Even setting aside the Carboniferous specimens above alluded to, of which the condition of the exterior is perhaps somewhat ambiguous, the species is still one of the oldest known *Lagenæ*. It occurs in the Middle Lias, the Oolite, and the Chalk, and at intervals throughout the Tertiary and Post-tertiary periods.

Lagena ampulla-distoma, Rymer Jones (Pl. LVII. fig. 5).

Lagena vulgaris, var. *ampulla-distoma*, Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 63, pl. xix. fig. 52.

The following is Mr. F. W. Owen Rymer Jones's description of this form. "The shell closely resembles some of the varieties of *Lagena globosa*, having the shape of a distended globe, the walls, however, being roughened by exogenous shell-deposit. From the anterior of the shell there projects an internal straight tube, passing three-fourths down the cavity, and terminating in a trumpet-shaped orifice; at the centre of the base, however, there projects a short external tube in the same axial line as the internal one."

The specimen above described was from off Sandalwood Island, coast of Java, 1080 fathoms; that figured in Pl. LVII. from off Raine Island, Torres Strait, 155 fathoms.

Lagena distoma-margaritifera, Parker and Jones (Pl. LVIII. fig. 16).

Lagena distoma-margaritifera, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 357, pl. xviii. fig. 6, *a.b.*

,, *synedra*, Gümbel, 1868, Abh. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 608, fig. 10, *a.b.*

This variety is described by Parker and Jones as "a large two-mouthed *Lagena*, never quite straight, richly ornamented with pearl-like grains, profusely spread over the

surface." The superficial ornament assumes a variety of aspects, ranging from the rounded wart-like excrescences indicated by Gümbel's drawing of *Lagena synedra*, to the oval or elongated beads of Parker and Jones's figure, and the irregular interrupted costæ shown in fig. 16. The features of the test in this respect are too variable to afford a basis for subdivision.

In the recent condition *Lagena distoma-margaritifera* is an Australian Foraminifer. It is stated to be common in sponge-sand from Melbourne; and it occurs sparingly in dredged sands from near East Moncœur Island, Bass Strait, 38 fathoms, and from the west coast of New Zealand, 275 fathoms.

Gümbel's specimens (*Lagena synedra*) were obtained from Nummulitic marls at three localities in the Bavarian Alps.

Lagena hispida, Reuss (Pl. LVII. figs. 1–4; Pl. LIX. figs. 2, 5).

"Sphærulæ *hispidæ*," Soldani, 1798, Testaceographia, vol. ii. p. 53, pl. xvii. figs. V. X.
Oolina salentina (?), Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 118, pl. xi. figs. 13, 14.
Lagena hispida, Reuss, 1858, Zeitschr. d. deutsch. geol. Gesellsch., vol. x. p. 434.
„ „ Id. 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 335, pl. vi. figs. 77–79.
„ *jeffreysii*, Brady, 1866, Report Brit. Assoc., Trans. Sections, p. 70.
„ *hispida*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 30, No. 15.

The shell of *Lagena hispida* assumes a great variety of forms, but it is almost invariably ectosolenian, the body being globular, pyriform, oval, or elongate and tapering, and the neck usually of considerable length. The surface is covered with fine bristle-like spines, closely set.

Under the name *Lagena hystrix*, Reuss has described and figured an allied variety, in which the hirsute aspect is due to short tube-like projections with truncate ends. It is perhaps open to question whether these are anything more than worn or broken spines.

Lagena hispida is a widely distributed but not a common species. It has been found in shallow water at several points on the northern and western shores of the British Islands; in the Faröe Channel, 540 fathoms; and in the North Atlantic, 435 to 1360 fathoms; at one Station in the South Atlantic, 1900 fathoms; at six in the South Pacific, 129 to 1825 fathoms; and at one in the North Pacific, 345 fathoms.

Its geological history extends back to the Middle Lias of France (Terquem and Berthelin); and it occurs subsequently in the Eocene deposits of Paris (Terquem), the Septaria-clays of Germany (Reuss), the Miocene and Pliocene of Southern Italy (Seguenza, Costa), and the Crag of the east of England (Jones, Parker, and Brady).

Lagena striata, d'Orbigny, sp. (Pl. LVII. figs. 22, 24, 28, 29, &c.).

Oolina striata, d'Orbigny, 1839, Foram. Amér. Mérid., p. 21, pl. v. fig. 12.
„ *haidingeri*, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 138, pl. xii. figs. 1, 2.
Lagena substriata, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 15, pl. ii. fig. 12.
„ *vulgaris*, var. *substriata*, Id., 1858, Rec. For. Gt. Br., p. 7, pl. i. fig. 14.
„ *gracilicosta*, Reuss, 1858, Zeitschr. d. deutsch. geol. Gesellsch., vol. x. p. 434;—1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 327, pl. iii. figs. 42, 43.
Ovulina striata, Seguenza, 1862, Foram. Monotal. Mess., p. 40, pl. i. figs. 6, 7.
„ *sulcata*, var. Id. Ibid. p. 41, pl. i. fig. 9.
Phialina haidingeri, Id. Ibid. p. 46, pl. i. fig. 20.
„ *tenuistriata*, Id. Ibid. p. 46, pl. i. fig. 21.
„ *lagena*, Id. Ibid. p. 46, pl. i. fig. 22.
„ *gemellarii*, Id. Ibid. p. 47, pl. i. fig. 23.
„ *cylindracea*, Id. Ibid. p. 47, pl. i. fig. 24.
Lagena tenuistriata, Stache, 1865, Novara-Exped., geol. Theil, vol. i., pt. 2, p. 184, pl. xxii. fig. 4.
„ *striata*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 35, pl. i. figs. 38–40.
Lagenulina striata, Terquem, 1876, Anim. sur la Plage de Dunkerque, fasc. 2, p. 68, pl. vii. fig. 7.
Lagena grinzingensis, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 378, pl. xvi, *b.*, fig. 17.

Few members of the genus have better defined and more easily recognised characters than *Lagena striata*, if judged only by specimens such as are found in shallow water on our own shores. The body of the shell is regularly oval, and it has a long tubular neck, and the surface is marked with numerous delicate, parallel, longitudinal striæ. Of this typical form Williamson gives an excellent figure in his *Lagena vulgaris*, var. *substriata*, Rec. For. Gt. Br., pl. i. fig. 14.

But outside the narrow area of the British seas these characters cease to apply in the same distinctive manner; and between the typical shell, with its closely set linear striæ, and the stoutly costate forms assigned to *Lagena sulcata*, every shade of variation is encountered; and the general contour of the test, whether with respect to the shape of the body or the nature of the apertural tube, presents equally inconstant features.

The finely striate varieties of *Lagena* have not quite the same universal distribution as those with stouter costæ, but they exist to a greater or less extent in almost every sea. They most affect shallow water, but are found from time to time down to 600 fathoms, and less frequently at even greater depths.

Lagena striata occurs as a fossil in the Septaria-clays of Germany (Reuss, Schlicht); in the Miocene of the Vienna Basin (Czjzek, Karrer), of Southern Italy (Seguenza) and of Malta (Brady); in the Pliocene of Italy (Seguenza); in the Crag of Antwerp (Reuss), and of the east of England (Jones, Parker, and Brady); and in the Post-tertiary beds of Norway, Scotland, England, Ireland, and Italy (Robertson, Shone, Wright, &c.).

Lagena lineata, Williamson, sp. (Pl. LVII. fig. 13).

Entosolenia lineata, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 18, pl. ii. fig. 18.
„ *globosa*, var. *lineata*, Williamson, 1858, Rec. For. Gt. Brit., p. 9, pl. i. fig. 17.
Lagena lineata, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 328, pl. iv. fig. 48.

Lagena lineata is an entosolenian modification of *Lagena striata*. The test is minute, and ovate or pyriform; the superior extremity rounded, and the inferior mucronate or sometimes furnished with a short projecting neck bearing a second aperture; the surface is covered partially or entirely with fine parallel lines, disposed longitudinally.

This variety is met with at many points on the coast of Great Britain, Belgium, and France, and also in the Faröe Channel. In the southern hemisphere it occurs on the shores of Tristan d'Acunha, 100 to 150 fathoms, and of Kerguelen Island, 20 to 50 fathoms.

It is found in the fossil state in the Post-tertiary beds of the west of Scotland (Robertson), and of the north-east of Ireland (Wright).

Lagena distoma, Parker and Jones (Pl. LVIII. figs. 11–15).

Lagena lævis, var. *striata*, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 278, pl. xi. fig. 24.
„ *distoma*, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 467, pl. xlviii. fig. 6.
„ *sulcata*, var. *distoma*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 356, pl. xiii. fig. 20.

The *Lagena distoma* of Parker and Jones includes the striate modifications of *Lagena gracillima* and *Lagena elongata*. Of these figs. 11 and 12 represent typical examples.

Such forms are tolerably abundant in the shallow-water margins of temperate latitudes, and are nowhere commoner than on our own shores. Their occurrence, however, is not entirely governed by depth of water, for specimens have been collected in the North Atlantic as far down as 1443 fathoms; in the South Atlantic, at 350 to 1900 fathoms; in the Southern Ocean, at 120 fathoms; in the South Pacific, at 155 to 275 fathoms; and in the North Pacific at 345 fathoms.

As a fossil *Lagena distoma* has been found in the Pliocene of Calabria (Seguenza), and in the Post-tertiary deposits of Norway (Crosskey and Robertson), and of the west of Scotland (Robertson).

Lagena variata, H. B. Brady (Pl. LXI. fig. 1).

Lagena variata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

Test subglobular or somewhat compressed; often gibbous, or otherwise asymmetrical in outline; entosolenian, sometimes distomous; surface-ornament consisting of irregular, interrupted, slightly raised, rounded, longitudinal riblets. Longer diameter, $\frac{1}{70}$th inch (0·36 mm.).

This is a rare form, with wrinkled rather than costate surface. It has been taken only off East Moncœur Island, Bass Strait, 38 fathoms.

Lagena sulcata, Walker and Jacob, sp. (Pl. LVII. figs. 23, 26, 33, 34; apiculate forms, Pl. LVIII. figs. 4, 17, 18, &c.).

"Orthocerata *perfecte globularia*," Soldani, 1780, Saggio Oritt., p. 108, pl. vi. fig. 43, *H.*
"Serpula (Lagena) striata sulcata rotundata," Walker and Boys, 1784, Test. Min., p. 2, pl. i. fig. 6.
"Polymorpha Sphærulæ *siphunculatæ*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 116, pl. cxix. fig. *R*; p. 118, pl. cxxix. fig. *c.c.*
Serpula (*Lagena*) *sulcata*, Walker and Jacob, 1798, Adams's Essays, Kanmacher's Ed., p. 634, pl. xiv. fig. 5.
Vermiculum striatum, Montagu, 1803, Test. Brit, pt. 2, p. 523.
„ *perlucidum*, Id. Ibid. p. 525, pl. xiv. fig. 3.
Oolina villardeboana, d'Orbigny, 1839, Foram. Amér. Mérid., p. 19, pl. v. figs. 4, 5.
„ *isabella*, Id. Ibid. p. 20, pl. v. figs. 7, 8.
„ *raricosta*, Id. Ibid. p. 20, pl. v. figs. 10, 11.
Lagena striata, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 13, pl. i. figs. 6, 8.
Miliola striata, Ehrenberg, 1854, Mikrogeologie, pl. xxiv. fig. 5; pl. xxxii. II. fig. 1.
Ovulina sicula, Id. Ibid. pl. xxvi. fig. 1.
„ *elegantissima*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 316, pl. xii. fig. 1.
Lagena vulgaris, var. *perlucida* (pars), Williamson, 1858, Rec. For. Gt. Br., p. 5, pl. i. fig. 8.
„ „ var. *striata*, Id. Ibid. p. 6, pl. i. fig. 10.
Entosolenia costata, Id. Ibid. p. 9, pl. i. fig. 18.
Ovulina sulcata, Seguenza, 1862, Foram. Monotal. Mess., p. 41, pl. i. fig. 8.
Phialina exigua, Id. Ibid. p. 47, pl. i. fig. 25.
„ *incerta*, Id. Ibid. p. 47, pl. i. fig. 26.
„ *costata*, Id. Ibid. p. 48, pl. i. fig. 27.
„ *costæ*, Id. Ibid. p. 48, pl. i. fig. 28.
„ *reussiana*, Id. Ibid. p. 48, pl. i. fig. 29.
Amphorina lyellii, Id. Ibid. p. 52, pl. i. fig. 40, apiculate variety.
„ *costata*, Id. Ibid. p. 52, pl. i. fig. 41, „ „
Lagena sulcata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 351, pl. xiii. figs. 24, 28–32 pl. xvi. figs. 6, 7.
„ *cæpulla*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 205, pl. iv. fig. 20, *a.b.*
„ *mucronulata*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 467, No. 8;—Schlicht, 1870, Foram. Pietzpuhl., pl. iii. figs. 18, 24, apiculate variety.
„ *laticosta*, Terquem and Berthelin, 1875, Mém. Soc. géol. France, sér. 2, vol. x. Mém. III. p. xv., pl. i. fig. 11.
„ *natrii*, Blake, 1876, Yorkshire Lias, p. 453, pl. xviii. fig. 8.
Lagenulina costata, Terquem, 1876, Anim. sur la Plage de Dunkerque, fasc. 2, p. 67, pl. vii. fig. 2.
Capitellina multistriata, Marsson, 1878, Mittheil. naturw. Vereine v. Neu-Vorpom. u. Rügen, Jahrg. x., p. 123, pl. i. fig. 3.
Lagena ornata, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 27, pl. i. fig. 12.

Lagena sulcata is regarded by Parker and Jones as the central representative of the genus, or in other words, as the typical species of which all the rest are, zoologically speaking, mere varietal, sub-varietal, or individual modifications. Without debating this point, there need be no hesitation in accepting the species as the type of the large and important group of non-compressed forms, characterised by longitudinal linear ornament.

The subordinate modifications are for the most part distinguished by the different degrees of development of features already present in the type, and in but few is there any new feature superadded.

It frequently happens that, in restricted areas, the striate or costate *Lagenæ* are divisible into tolerably well-marked groups, which it is impossible to preserve when gatherings from wider limits or more extended bathymetrical range are taken into account. This fact has already been adverted to in the case of *Lagena striata*. I am assured by my friend Mr. Joseph Wright of Belfast, who has given much attention to the subject, that in the Irish (and therefore presumably in the British) seas, there are two modifications of *Lagena sulcata*, namely, *Lagena williamsoni* and *Lagena costata*, which are always distinguishable from the typical form; the former by a ring of reticulated or hexagonal ornament at the base of the neck, the latter by the really sulcate rather than costate condition of the surface. Of these, *Lagena williamsoni* at any rate is probably a good local variety, the characters partaking more or less of those of *Lagena hexagona;* but there is much less to go upon in the case of *Lagena costata*, which, viewed from a wider standpoint, appears only as one of innumerable individual modifications of the parent form.

Lagena sulcata is one of the most abundant and most generally diffused of all the members of the genus. It is at home in every latitude from Baffin's Bay and Smith Sound or the shores of Novaya Zemlya, to the equator; and from the equator to Heard Island, far south in the Southern Ocean; and the bathymetrical range extends from the littoral zone to a depth of 2750 fathoms.

Its geological history is similarly extensive. It has been discovered by Mr. John Smith of Kilwinning, in shales of Upper Silurian age, at Lincoln Hill, Woolhope, and a very similar though perhaps varietally distinct form occurs in the Carboniferous Limestones of the north of England and of Scotland. It is present in the Lower Lias of Yorkshire (Blake), and recurs in almost every subsequent microzoic deposit down to recent times.

Lagena sulcata, var. *interrupta*, Williamson (Pl. LVII. figs. 25, 27; apiculate specimens, Pl. LVIII. figs. 5, 6).

Lagena striata, var. *interrupta*, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 14, pl. i. fig. 7.
„ *vulgaris*, var. *interrupta*, Id. 1858, Rec. For. Gt. Br., p. 7, pl. i. fig. 11.
„ *alternans*, Terquem, 1875, Anim. sur la Plage de Dunkerque, p. 21, pl. i. fig. 4.
„ *interrupta*, Id. 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III. p. 27, pl. i. fig. 10.

As stated by Williamson, this variety only differs from the typical *Lagena sulcata*, "in the unequal lengths and discontinuous character of the costæ, which sometimes do not extend over more than one half of the shell."

The distribution is practically identical with that of the type.

Lagena acuticosta, Reuss (Pl. LVII. figs. 31, 32; Pl. LVIII. figs. 20 (?) 21).

Lagena acuticosta, Reuss, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 305, pl. i. fig. 4.
„ „ Id. 1862, Ibid. vol. xlvi. p. 331, pl. v. fig. 63.
„ „ Id. 1870, Ibid. vol. lxii. p. 467, No. 10;—Schlicht 1870, Foram. Pietzpuhl, pl. iii. figs. 17, 23.

A variety distinguished from the typical *Lagena sulcata* by having comparatively few, thin, much elevated costæ, frequently of unequal size.

The best recent examples of *Lagena acuticosta* are chiefly from deep water in the North and South Pacific; but it would be almost impossible to lay down any lines of distribution distinct from those of *Lagena sulcata*.

Reuss figures a specimen from the Chalk of Maestricht, and Schlicht two or three from the Septaria-clay of Pietzpuhl.

Lagena gracilis, Williamson (Pl. LVIII. figs. 2, 3, 7–10, 19, 22–24).

Lagena gracilis, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 13, pl. i. figs. 3, 4.
„ *vulgaris*, var. *gracilis*, Id. 1858, Rec. For. Gt. Br., p. 7, pl. i. figs. 12, 13.
„ *gracilis*, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 331, pl. iv. figs. 58–61; pl. v. fig. 62.
„ „ Siddall, 1879, Catal. Brit. Rec. For., p. 5.

This is the striate or finely costate modification of *Lagena clavata*. The test is much elongated, tapering to a point at the base, and finishing at the anterior end in a tubular neck.

The geographical distribution of *Lagena gracilis* is world-wide. It is a not uncommon shallow-water Foraminifer on the western shores of Europe, but the Challenger specimens are chiefly from deep bottoms in the southern hemisphere:—from the South Atlantic, 1900 to 2775 fathoms; the Southern Ocean, 50 to 2600 fathoms; and the South Pacific, 129 to 2425 fathoms.

Its range in time embraces the Chalk of Rügen (Marsson), the Septaria-clay of Pietzpuhl (Reuss, Schlicht), the Pliocene of Calabria (Seguenza), and of Kar Nicobar (Schwager), and the Post-pliocene of Norway (Crosskey and Robertson), and of the north-east of Ireland (Wright).

Lagena quadralata, H. B. Brady (Pl. LXI. fig. 3, *a.b.*).

Lagena quadralata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 62.

Test flask-shaped, ectosolenian; furnished with four equidistant, broad, tubulated, lamelliform wings, reaching from near the extremity of the neck to the base of the shell;

the body of the test having an additional surface-ornament of longitudinal striæ or costæ. Length, $\frac{1}{70}$th inch (0·36 mm.).

This form is allied to the *Lagena alifera* of Reuss, but the wings are only four in number and conspicuously tubulated, and the intermediate portions of the test are striate or costate.

Lagena quadralata is a rare deep-water variety, only found hitherto at two localities, namely:—Station 160, south of Australia, 2600 fathoms; and Station 332, South Atlantic, mid-ocean, 2200 fathoms.

Lagena plumigera, H. B. Brady (Pl. LVIII. figs. 25, 27).

Lagena plumigera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 62.

Test flask-shaped, with long, slender, ectosolenian neck; surface-ornament consisting of ten or twelve longitudinal costæ, the inferior portions of which are developed into wide, feather-like, tubulated wings. Length, $\frac{1}{40}$th inch (0·63 mm.).

An exuberant deep-water modification of *Lagena sulcata*, the best specimens of which have been obtained from the tropical regions of the South Pacific, at depths of 2425 fathoms and 2350 fathoms, and less characteristic examples from near the Cape de Verde Islands, 1070 fathoms.

Lagena semistriata, Williamson (Pl. LVII. figs. 14, 16, 17 [18, 20 ?]).

Lagena striata, var. *semistriata*, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 14, pl. i. figs. 9, 10.
Oculina lachryma, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 307, pl. xii. fig. 2.
„ *tenuis*, Id. Ibid., pl. xii. figs. 3, 3*.
Oolina punctata, Egger, 1857, Neues Jahrb. fur Min. &c., p. 268, pl. v. figs. 1, 2.
„ *striatula*, Id. Ibid. p. 269, pl. v. figs. 3–8.
Lagena vulgaris, var. *semistriata*, Williamson, 1858, Rec. For. Gt. Br., p. 6, pl. i. fig. 9.
Phialina longissima, Seguenza, 1862, Foram. Monotal. Mess., p. 45, pl. i. fig. 18.
„ *semicostata*, Id. Ibid. p. 45, pl. i. fig. 19.
Lagena sulcata, var. *semistriata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 350, pl. xiii. fig. 23.
„ *semistriata*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 34, pl. iv. fig. 6.

Lagena semistriata is the name applied to a group of intermediate forms presenting considerable diversity of contour, but characterised by the partial nature of the surface-ornament, which consists of costæ, springing from the base of the shell but terminating, often abruptly, before reaching the middle.

The distribution naturally follows that of *Lagena lævis* and *Lagena sulcata*, and wherever the types abound the intermediate forms may be expected.

Lagena multicosta, Karrer, sp. (Pl. LXI. fig. 4).

Fissurina multicosta Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 379, pl. xvi. *b*, fig. 20.
„ *bouei*, Id. Ibid. p. 378, pl. xvi. *b*, fig. 19.

Karrer has figured (*loc. cit.*) two *Lagenæ*, the characters of which do not differ from each other to a greater degree than is common amongst individuals of the same variety, especially in cases where the deviation from the typical features is only slight.

The figures in question represent nearly globular shells with a surface-ornament of raised costæ extending from the base to near the middle of the test, and then thinning out so as to leave the upper portion smooth. In one of the shells the costæ are numerous and some of them bifurcated; in the other they are fewer in number and are all in the normal unbranched condition. Such specimens are often more or less compressed bilaterally, and the aperture is correspondingly elongated, so that they may be supposed to exemplify the fissurine condition of *Lagena semistriata*.

The figured recent specimen is from Station 346, South Atlantic, a little south of the equator, 2350 fathoms.

Those depicted in the original drawings were from the Miocene of the Vienna Basin.

Lagena stelligera, H. B. Brady (Pl. LVII. figs. 35, 36).

Lagena stelligera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 60.

Shell pyriform, ento- or ecto-solenian; with a deep, vertical, circular rim or collar at the base, about-one third the diameter of the shell, and a number of short ribs (eight to twelve) radiating from it. Surface otherwise smooth. Length, $\frac{1}{50}$th inch (0·5 mm.), or less.

The shell of *Lagena stelligera* may easily pass unnoticed, owing to its resemblance to the final segment of a Nodosarian, and the similarity is often increased by its assuming a somewhat inequilateral contour. The base, however is always imperforate, and the aperture very frequently entosolenian. The circular rim varies considerably in depth, and the costæ are sometimes little more than bridges fitting the angle between it and the rounded base, though in other cases they extend to nearly one-third the height of the test. In rare instances, they are entirely wanting.

Lagena stelligera is a deep-water Foraminifer. It has been met with altogether at fourteen localities, embracing Stations in both the North and South Atlantic, the North and South Pacific, and the Southern Ocean. In eight of these the depths range between

2300 and 2740 fathoms, and of the remainder only three have a depth of less than 1300 fathoms.

Lagena crenata, Parker and Jones (PL. LVII. figs. 15, 21).

Lagena crenata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 420, pl. xviii. fig. 4, *a.b.*
„ „ Brady, 1866, Report Brit. Assoc., Trans. Sections, p. 70.

This pretty variety is described by its authors in the following terms :—"Test decanter-shaped, neck long and coiled; body gradually widening and smooth to the base, which for half its radius is widely and deeply crenate with broad radiating furrows; the centre of the base being smooth and gently convex." Length, about $\frac{1}{50}$th inch (0·5 mm.).

Lagena crenata is a somewhat rare form, and though it has been found in a considerable number of localities it is nowhere abundant. The distribution-list includes several points in the British seas, at depths of less than 60 fathoms; the North Atlantic, west of Ireland, 183 fathoms; the Cape of Good Hope, 15 to 20 fathoms; Australian shore-sands; off East Moncœur Island, Bass Strait, 38 fathoms; and three Stations, in deep water in the South Pacific, 2325 to 2425 fathoms.

It occurs as a fossil in the Middle Tertiaries of Bordeaux and Malaga (Parker and Jones), and in the Post-tertiary deposits of Southern Italy (Seguenza).

Lagena exsculpta, H. B. Brady (PL. LVIII. fig. 1; PL. LXI. fig. 5).

Lagenulina sulcata, Terquem, 1876, Anim. sur la Plage de Dunkerque, fasc. 2, p. 68, pl. vii. fig. 9.
Lagena exsculpta, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.
Lagena florida, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III. p. 26, pl. i. fig. 9.

Test subglobular or pyriform, rounded or compressed, entosolenian; surface ornament consisting of excavated furrows radiating from the centre of the inferior end; radii fluted, broad and rounded at their anterior margins, sometimes bordered, extending nearly to the middle of the test. Length, $\frac{1}{60}$th inch (0·42 mm.), more or less.

A somewhat rare variety, in which partial sculptured ornament takes the place of the usual exogenous thickening.

But few specimens of *Lagena exsculpta* have been met with, and these are from localities far apart, namely :—one Station in the North Pacific, depth 2300 fathoms; two in the South Pacific, 800 fathoms and 1100 fathoms respectively; south of Australia, 2600 fathoms; the Antarctic Ice-barrier, 1300 fathoms; and one point in the South Atlantic, 1425 fathoms. Terquem records a similar form from the French coast.

A shell with almost identical characters, *Lagena florida*, is figured by the same

author in his recent memoir on the Foraminifera of the Eocene beds of the neighbourhood of Paris.

Lagena striatopunctata, Parker and Jones (Pl. LVIII. figs. 37, 40).

Lagena sulcata, var. *striatopunctata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 350, pl. xiii. figs. 25–27.

Entosolenia striatopunctata, G. M. Dawson, 1870, Canad. Nat., N. S. vol. v. p. 178, woodcut, p. 180, fig. 11.

Lagena seriato-granulosa, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 468, No. 16;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxxviii. fig. 20.

Lagena striatopunctata, Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 434, pl. xx. fig. 3.

The test of *Lagena striatopunctata* is oval, pyriform, or flask-shaped, and either ecto- or ento-solenian. It is decorated externally with tolerably stout longitudinal costæ, from six to twenty in number, bearing conspicuous pseudopodial foramina. The perforations are placed either in single rows down the middle of the costæ, or in double lines, one on each side in their thickened bases.

The species is by no means common, but occasional specimens are met with in areas very far apart. The distribution-list embraces localities in the Arctic Seas, the North and South Atlantic, and the North and South Pacific, the depths ranging from 55 to 2750 fathoms. It occurs sparingly in comparatively shallow water on our own shores.

Lagena striatopunctata is one of the fossil Foraminifera found by von Schlicht in the Septaria-clay of Pietzpuhl, in North Germany. It occurs in the Post-tertiary deposits of the west of Scotland (Robertson), and in those of the north-east of Ireland (Wright).

Lagena spiralis, n. sp. (Pl. CXIV. fig. 9).

Test pyriform, ectosolenian; surface decorated with a small number of longitudinal costæ, arranged spirally, and having a row of conspicuous perforations along the centre of each. Length, $\frac{1}{150}$th inch (0·17 mm.).

This is a variety of *Lagena striatopunctata* with a test of minute size, adorned with spirally twisted instead of straight ribs.

The figured specimen was found by Mr. Joseph Wright in the rich coral-sand from Raine Island, Torres Strait, 155 fathoms.

Lagena desmophora, Rymer Jones (Pl. LVIII. figs. 42, 43).

Lagena vulgaris, var. *desmophora*, Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 54, pl. xix. figs. 23, 24.

This form is described by Mr. F. Rymer Jones (*loc. cit.*) in the following terms:—"Shell hyaline, smooth; ovate, sometimes elongated, flask-shaped, passing anteriorly into a more

or less produced slender neck, the end of which becomes slightly patulous and thickened round the rim. Internal tube of variable length. Externally the walls are decorated with about six bands of chain-work, passing from the base to the commencement of the neck." It may be added, that in one of the figures accompanying the description, the whole of the ornament is of this catenulate character; whilst the other exhibits in addition two wing-like costæ at opposite points of the periphery.

Amongst the Challenger specimens even greater diversity is observable. Generally the chain-like bands alternate with solid costæ of the normal kind, as in Pl. LVIII. fig. 42; and sometimes the alternation is only one of the former to two of the latter, as in fig. 43. It is obvious that the catenulate ornament is a modification of the perforated costæ of such forms as *Lagena striatopunctata*.

Lagena desmophora has been observed at two Stations in the North Atlantic, depth 390 fathoms and 2350 fathoms respectively; at one in the South Atlantic, 675 fathoms; at three in the South Pacific, from 1375 to 2350 fathoms; and at one in the North Pacific, 1850 fathoms; in addition to the locality at which the original specimens were obtained, namely, off Sandalwood Island, coast of Java, 1080 fathoms.

Lagena torquata, H. B. Brady (Pl. LVIII. fig. 41).

Lagena torquata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N.S., p. 62.

Test flask-shaped, with tapering cetosolenian neck; surface-ornament consisting of a number of broad longitudinal costæ, with depressions or perforations at regular intervals down the centre of each, like the catenulate lines in *Lagena desmophora;* and alternating with these an equal number of narrower, imperforate ribs,—the whole united by a series of secondary or less elevated transverse bands. Length, $\frac{1}{45}$th inch (0·56 mm.).

This is a modification of *Lagena desmophora*, distinguished by the transverse bands, which form with the costæ a sort of surface-reticulation.

The single recorded habitat is the South Pacific, just north of Juan Fernandez, 1375 fathoms.

Lagena feildeniana, H. B. Brady (Pl. LVIII. figs. 38, 39).

Lagena feildeniana, Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 434, pl. xx. fig. 4.

This also is a striato-punctate variety, but the lines of perforations are situated in the intercostal furrows instead of on the costæ.

It is a rare form, found sparingly in about half a dozen localities, as follows:—Smith Sound, off Cape Frazer, lat. 79° 45′ N., 80 fathoms; Southern Ocean, west of Prince Edward Island, 1570 fathoms; off Sydney, 410 fathoms; off Tahiti, 620 fathoms; at one

Station in the North Pacific, 2300 fathoms; and at one in the South Atlantic, 2200 fathoms It has also been dredged by Balkwill and Wright in Dublin Bay, 45 fathoms.

Lagena hertwigiana, H. B. Brady (Pl. LVIII. fig. 36, *a.b.*, woodcut, fig. 12).

Lagena hertwigiana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 62.

Test pyriform, with delicate ectosolenian neck rising abruptly from the apex. Surface finely reticulated, each angular mesh with a conspicuous perforation in the centre. Sections show that the shell-wall is double, that the intermediate space is divided into cells or chamberlets by perpendicular walls, of which the external areolation marks the position, and that the larger perforations open into the cells. Length, $\frac{1}{75}$th inch (0·34 mm.).

The external features of *Lagena hertwigiana* are well depicted in fig. 36, to a scale of 75 diameters; and the minute structure of the shell-wall is indicated by the annexed woodcuts, which represent longitudinal and transverse sections, magnified 200 diameters. The neck is a prolongation of the inner or primary shell. In abraded or worn specimens the test presents a soft and spongy appearance, owing to the cellulated pithlike structure of the external or supplementary shelly growths.

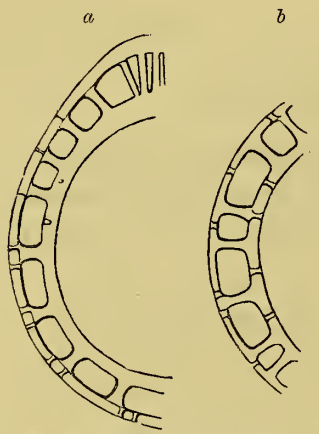

Fig. 12.—*Lagena hertwigiana.*

a. Longitudinal section of the shell.
b. Transverse section.
Magnified 200 diam.

Morphologically, the cellulation of the shell-wall may be supposed to have its origin in the reticulated form of ornament, the raised network being closed-in by the formation of a thin exterior shelly lamina.

A variety differing slightly from the figured specimen is occasionally met with, in which the perforations are arranged in nearly regular equidistant lines, precisely as may be seen in the later segments of *Nodosaria intercellularis*. This is probably directly related to the group of forms in which the reticulated ornament consists of longitudinal costæ and transverse bars.

The best examples of *Lagena hertwigiana* have all been obtained from one locality, off Raine Island, Torres Strait, 155 fathoms, where both varieties are found. Less characteristic specimens occur at Station 160, south of Australia, 2600 fathoms; and similar forms have been dredged by the Rev. A. M. Norman on the coast of Norway, south of Bukken, near Bergen, 150 to 200 fathoms.

Lagena squamosa, Montagu, sp. (Pl. LVIII. figs. 28–31).

"Polymorpha Sphærulæ *siphunculatæ*," Soldani, 1791, Testaceegraphia, vol. i. pt. 2, p. 116, pl. cxix. figs. *P. Q.*; pl. cxx. figs. *cc. ee, &c.*

Vermiculum squamosum, Montagu, 1803, Test. Brit., p. 526, pl. xiv. fig. 2.

Lagenula reticulata, Macgillivray, 1843, Moll. Anim. Aberd., p. 38.

Entosolenia squamosa, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. pl. ii. fig. 19.

„ *globosa*, var. *squamosa*, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 278, pl. xi. fig. 25.

„ *squamosa*, Williamson, 1858, Rec. For. Gt. Br., p. 12, pl. i. fig. 29.

Lagena reticulata, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 333, pl. v. figs. 67, 68.

Phialina ornata, Seguenza, 1862, Foram. Monotal. Mess., p. 48, pl. i. fig. 30.

Lagena anomala, Stache, 1865, Novara-Exped., geol. Theil, vol. i. pt. 2, p. 183, pl. xxii. fig. 5.

„ *squamosa*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 39, pl. iv. fig. 7.

Lagena squamosa may be taken as the type of a considerable section of the genus, characterised by the linear reticulation, in one form or other, of the surface of the test. The specific term is aptly applied to the sort of ornament depicted in Montagu's original figure which resembles nothing so much as the arrangement of the scales on the skin of a fish. The areæ corresponding to scales are of equal size and of nearly uniform outline, the superior margins being arched, the inferior angular; but they are not arranged on any methodical plan. A specimen with somewhat similar characters is portrayed in Pl. LVIII. fig. 28, but the meshes are disposed in nearly regular vertical lines.

Sometimes the reticulation is more distinctly geometrical, and the meshes assume the form of regular hexagons, such modifications constituting the "var. *hexagona*" of Williamson. Another variety results from the formation of longitudinal ribs, with cross-bars of equal height and substance, the meshes being small and approximately square or somewhat rounded; this is exemplified in the *Lagena melo* of d'Orbigny. Sometimes the cross-bars are of slighter substance and less elevated than the main ribs, and the test resembles that of *Lagena sulcata* with the addition of thin transverse lines between the costæ. Specimens so constructed are assigned by Reuss to the *Lagena catenulata* of Williamson; but Williamson's figure of that species clearly belongs to *Lagena melo*, and it is a question whether it is worth while attempting to separate the forms referred to from the typical, less regularly ornamented, *Lagena squamosa*. The *Lagenula reticulata* of Macgillivray is described as having "reticulated markings bounding irregular-areolar spaces," and in the absence of any figure, there need be no hesitation in associating it with the present species.

Lagena squamosa is met with in almost every sea, but it is not so abundant as many of its congeners. Though found from time to time on deep bottoms, even down to 2300 fathoms, it manifestly prefers comparatively shallow water, and at a large proportion of the known localities the registered depth is less than 100 or 150 fathoms.

There is no record of its occurrence as a fossil prior to the Eocene of the Paris Basin,

but in subsequent formations it is not uncommon, either in the typical or some of the varietal forms.

Lagena hexagona, Williamson, sp. (Pl. LVIII. figs. 32, 33).

Entosolenia squamosa, var. *hexagona*, Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 20, pl. ii. fig. 23.
„ „ „ Id. 1858, Rec. For. Gt. Br., p. 13, pl. i. fig. 31.
„ „ var. *scalariformis*, Id. Ibid. p. 13, pl. i. fig. 30.
Lagena squamosa, Parker and Jones, 1862, Introd. Foram., App., p. 309.
„ *favosa*, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 334, pl. v. figs. 72, 73.
„ *geometrica*, Id. Ibid. p. 334, pl. v. fig. 74.
Ovulina ornata, Seguenza, 1862, Foram. Monotal. Mess., p. 42, pl. i. fig. 12.
Lagena sulcata, var. (*Entosolenia*) *squamosa*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 354, pl. xiii. figs. 40, 41 ; pl. xvi. fig. 11, *a. b.*
„ *mariæ*, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 378, pl. xvi. *b*, fig. 16.
„ *hexagona*, Siddall, 1879, Catal. Brit. Rec. For., p. 6.

As already stated, this variety includes those modifications of *Lagena squamosa* in which the raised surface-reticulation is laid out in regular hexagons.

In the recent condition it is less common than the typical form, but it inhabits a similarly wide geographical area, and affects the same bathymetrical conditions.

Its geological distribution is restricted to the Tertiary epoch. It is found in the *Clavulina-szabói* beds of Hungary (Hantken) ; in the Miocene of the Vienna Basin (Karrer), and of Southern Italy (Seguenza) ; in the Salzthon of Wieliczka (Reuss) ; in the Crag of the east of England (Jones, Parker, and Brady), and in the Post-tertiary formations of the west of Scotland (Robertson), and of the north-east of Ireland (Wright).

Lagena seminuda, n. sp. (Pl. LVIII. fig. 34, *a.b.*).

Test subglobular or somewhat pyriform, entosolenian ; orifice frequently situated in a cup-like depression of the anterior extremity ; surface-ornament, consisting of a raised reticulation, confined to the posterior half of the shell. Length, $\frac{1}{60}$th inch (0·42 mm.).

This is a deep-water variety of *Lagena squamosa*, with stout globose shell, the exterior of which is only partially ornamented, the oral end being left smooth.

The Challenger specimens are from two Stations in the South Atlantic, and four in the South Pacific, the depths ranging from 1300 to 2350 fathoms. It has, however, been found in shallower water in the North Atlantic.

Lagena favoso-punctata, H. B. Brady (Pl. LVIII. fig. 35; Pl. LIX. fig. 4; Pl. LXI. fig. 2).

Lagena favoso-punctata, Brady, 1881, Quart. Journ., Micr. Sci., vol. xxi., N. S., p. 62.

Test ecto- or ento-solenian, shape variable; surface areolated or reticulated, with a conspicuous orifice or perforation in the middle of each area or depression. Length, $\frac{1}{75}$th inch (0·34 mm.), or less.

The three figures grouped under this varietal name differ a good deal in point of form, one being pyriform and ectosolenian, another subglobular, caudate, and entosolenian, and the third, oval, compressed, and wide-mouthed; but they agree in the character of their surface-ornament.

The specimens were all obtained on the shores of New Guinea, two of them from the north coast, 17 fathoms, the other from Torres Strait, 155 fathoms.

Lagena lævigata, Reuss, sp. (Pl. CXIV. fig. 8, *a.b.*).

Fissurina lævigata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 366, pl. xlvi. fig. 1, *a.b.*
„ *globosa*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 317, pl. xii. fig. 4.
„ *simplex*, Seguenza, 1862, Foram. Monotal. Mess., p. 56, pl. i. fig. 44.
„ *deltoidea*, Id. Ibid. p. 57, pl. i. fig. 45.
„ *latistoma*, Id. Ibid. p. 57, pl. i. figs. 46, 47.
„ *biancæ*, Id. Ibid. p. 57, pl. i. figs. 48–50.
„ *acuta*, Id. Ibid. p. 57, pl. i. fig. 51.
Lagena lævigata, Robertson, 1883, Trans. Geol. Soc. Glasgow, vol. vii. p. 24.

Of the bilaterally compressed varieties of the genus, *Lagena lævigata* is the simplest. The general outline of the test is pyriform; the apertural end slightly drawn out, the two faces convex, and the peripheral edge subangular. The aperture is entosolenian, and the external orifice generally, though not always, a long slit on the median line at the narrower extremity of the shell.

Lagena lævigata is found in every part of the world. The Challenger collections have yielded specimens from depths ranging from 2 fathoms to 3125 fathoms.

It has been observed in the Chalk of Rügen (Marsson), in the Eocene deposits of Paris (Terquem), in the Septaria-clays of Germany and in the Salzthon of Wieliczka (Reuss), in the Miocene of Vienna (Czjzek), and of Lower Bavaria (Egger); in the Miocene and Pliocene of Southern Italy (Seguenza), and in the Post-tertiary clays of the west of Scotland (Robertson).

Lagena acuta, Reuss, sp. (Pl. LIX. fig. 6, *a.b.*?).

Fissurina acuta, Reuss, 1858, Zeitschr. d. deutsch. geol. Gesellsch., vol. x. p. 434.
„ „ Id. 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 340, pl. vii. figs. 90, 91.
Lagena vulgaris, var. *fissurina* (pars), Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 51, pl. xxix. fig. 6.

Lagena acuta bears much the same relation to *Lagena lævigata* that *Lagena apiculata* bears to *Lagena globosa;* in other words, it is the subvarietal modification in which the base is drawn out to a point instead of being rounded. The shell figured on Pl. LIX. is not quite typical and might with equal propriety be treated as a mucronate example of *Lagena marginata.*

The distribution of *Lagena acuta*, whether living or fossil, is probably coextensive with that of *Lagena lævigata.*

Lagena staphyllearia, Schwager, sp. (Pl. LIX. figs. 8–11).

Fissurina staphyllearia, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 209, pl. v. fig. 24.
Lagena vulgaris, var. *spinicosto-marginata*, Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 57, pl. xix. figs. 34–36.

The compressed *Lagenæ* with symmetrically arranged basal spines may be assigned to *Lagena staphyllearia.* The pointed processes of recent specimens are usually placed at regular intervals on the median line, as shown in figs. 8–10. Occasionally a deviation from the typical condition is encountered in the form of double spines, of which fig. 11 is an example.

In the North and South Atlantic *Lagena staphyllearia* has only been observed at great depths, namely at four Stations, ranging from 2200 to 2750 fathoms; but in the Southern Ocean and the South Pacific it occurs also from time to time in shallow water near the coast-line.

The fossil shell figured by Schwager was from the Upper Pliocene deposit of Kar Nicobar.

Lagena unguiculata, H. B. Brady (Pl. LIX. fig. 12).

Lagena unguiculata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

Test pyriform, compressed; inferior end broad and tapering to a thin edge, which is furnished with a number of more or less curved teeth symmetrically set.

A rare variety, differing but little from *Lagena staphyllearia.* It occurs in the South Atlantic, at Station 332, depth 2200 fathoms.

Lagena quadrata, Williamson, sp. (Pl. LIX. figs. 3, 16; Pl. LX. fig. 5).

Entosolenia marginata, var. *quadrata*, Williamson, 1858, Rec. For. Gt. Br., p. 11, pl. i. figs. 27, 28.
Fissurina pecchiolii, Seguenza, 1862, Foram. Monotal. Mess., p. 58, pl. i. fig. 52.
„ *recta*, Id. Ibid. p. 58, pl. i. fig. 53.
„ *oblonga*, Id. Ibid. p. 68, pl. ii. fig. 35.

Williamson describes this variety as "an obvious modification of *Entosolenia marginata*, var. *lucida*, distinguished by its tendency to assume the form of a parallelogram, with somewhat rounded extremities."

Considerable latitude, however, must be allowed with respect to minor characters. For example, the specimen represented by Pl. LIX. fig. 3, has a wide orifice with sessile lip, and fig. 16 is in all respects similar, except that the margin at the inferior end is carinate; whilst in the shell of which Pl. LX. fig. 5 is a drawing, the entire periphery is carinate. Seguenza has a closely allied carinate variety, under the name *Fissurina rizzæ*, (*op. cit.*, pl. ii. fig. 50), distinguished from the last by its more or less produced phialine neck and rounded orifice.

The distribution of *Lagena quadrata* appears to be influenced by depth of water more than by latitude. It is found, both in the northern and southern hemispheres, at depths of less than 150 fathoms, but the specimens are never very numerous.

As a fossil it occurs in the Miocene and Pliocene deposits of Southern Italy (Seguenza), and in the Post-tertiary beds of the north-east of Ireland (Wright), but has not been observed elsewhere.

Lagena trigono-oblonga, Seguenza and Siddall (PL. LXI. fig. 11, *a.b.*).

Trigonulina oblonga, Seguenza, 1862, Foram. Monotal. Mess., p. 74, pl. ii. figs. 56, 58.
„ *biangulata*, Id. Ibid. p. 74, pl. ii. figs. 57, 59.
„ *regolaris*, Id. Ibid. p. 75, pl. ii. figs. 63, 64.
Lagena oblonga, Wright, 1877, Proc. Belfast Nat. Field Club, 1876-7, App. p. 104, pl. iv. fig. 9, *a.b.*
„ (*trigono-*) *oblonga*, Siddall, 1879, Catal. Rec. For. Gt. Br., p. 5.

The shell of this species resembles that of a pyriform specimen of *Lagena globosa*, more or less compressed on three sides; the marginal edges are either angular or slightly rounded, and the aperture is entosolenian. The trifacial compression of the test was treated by Seguenza as a generic character and the specific term "*oblonga*," which takes precedence for the present form, does not happen to be very appropriate in its altered connection. The prefix suggested by Mr. Siddall may be adopted with advantage, and will probably obviate confusion.

Lagena trigono-oblonga has only been noticed at one Challenger Station,—off Tahiti, 620 fathoms. It has been collected by Siddall in the estuary of the Dee, and by Balkwill and Wright in Dublin Bay.

Seguenza's fossil specimens were from the Miocene deposits of Sicily. It is also recorded in Wright's catalogue of the Post-tertiary Foraminifera of the north-east of Ireland.

Lagena marginata, Walker and Boys (Pl. LIX. figs. 21–23).

"Serpula (*Lagena*) marginata," Walker and Boys, 1784, Test. Min., p. 2, pl. i. fig. 7.
Vermiculum marginatum, Montagu, 1803, Test. Brit., p. 524.
Oolina compressa, d'Orbigny, 1839, Foram. Amér. Mérid., p. 18, pl. v. figs. 1, 2.
Entosolenia marginata (pars), Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. i. p. 17, pl. ii. figs. 15–17.
Fissurina alata, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 58, pl. iii. fig. 1.
,, *carinata*, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxvi. p. 338, pl. vi. fig. 83; pl. vii. fig. 86.
,, *communis*, Seguenza, 1862, Foram. Monotal. Mess., p. 59, pl. i. figs. 56, 57.

,, *propinqua*,	Id.	Ibid.	p. 59, pl. i. fig. 58.
,, *ardasii*,	Id.	Ibid.	p. 59, pl. i. fig. 59.
,, *aperta*,	Id.	Ibid.	p. 60, pl. i. fig. 60.
,, *obvia*,	Id.	Ibid.	p. 60, pl. ii. fig. 1.
,, *tenuis*,	Id.	Ibid.	p. 60, pl. ii. fig. 2.
,, *elliptica*,	Id.	Ibid.	p. 60, pl. ii. fig. 3.
,, *ovata*,	Id.	Ibid.	p. 62, pl. ii. figs. 9, 10.
,, *benoitiana*,	Id.	Ibid.	p. 62, pl. ii. fig. 11.
,, *haeckelii*,	Id.	Ibid.	p. 63, pl. ii. fig. 13.
,, *circulum*,	Id.	Ibid.	p. 63, pl. ii. fig. 15.
,, *silvestrii*,	Id.	Ibid.	p. 64, pl. ii. fig. 18.
,, *emarginata*,	Id.	Ibid	p. 65, pl. ii. fig. 20.
,, *dilatata*,	Id.	Ibid.	p. 65, pl. ii. fig. 21.
,, *lævis*,	Id.	Ibid.	p. 66, pl. ii. figs. 22, 23.
,, *sulcata*,	Id.	Ibid.	p. 67, pl. ii. fig. 29.
,, *tubulosa*,	Id.	Ibid.	p. 68, pl. ii. figs. 36, 37.
,, *regolaris*,	Id.	Ibid.	p. 71, pl. ii. fig. 46.
,, *sartorii*,	Id.	Ibid.	p. 71, pl. ii. fig. 47.
,, *lyellii*,	Id.	Ibid.	p. 71, pl. ii. figs. 48, 49.

Lagena sulcata, var. (*Entosolenia*) *marginata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 355, pl. xiii. figs. 42–44; pl. xvi. fig. 12, *a. b.*
Fissurina alata, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 469, No. 2;—Schlicht, 1870, Foram. Pietzpuhl, pl. iv. figs. 7–9, 13–15; pl. v. figs. 19–21.
Lagena vulgaris, var. *petasma-marginata*, Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 58, pl. xix. figs. 38, 39.

,, ,,	var. *bracteato-marginata*,	Id.	Ibid.	p. 59, pl. xix. figs. 40, 41.
,, ,,	var. *alato-marginata*,	Id.	Ibid.	p. 60, pl. xix. fig. 44.
,, ,,	var. *clavato-marginata*,	Id.	Ibid.	p. 60, pl. xix. fig. 45.
,, ,,	var. *pertuso-marginata*,	Id.	Ibid.	p. 61, pl. xix. figs. 46, 47.

Lagena marginata includes those compressed varieties of the type of which the peripheral edge is carinate to a greater or less degree. In some cases the carina is only sufficient to form a thin sharp margin, whilst in others it is developed into a lamelliform

wing, which under exceptional circumstances may attain a width equal to one-third the diameter of the body of the shell. The aperture is entosolenian and the external orifice generally Fissurine. Reuss has attempted to separate specifically the specimens with wide from those with narrow keel, grouping the former under the name *Fissurina alata;* but this is a distinction which it is altogether impossible to carry out in practice.

Specimens are occasionally met with in which the keel or wing has a more or less serrate edge. Williamson's figure (Rec. For. Gt. Br., pl. i. fig. 21, *a*) represents a shell of this sort; and Seguenza gives a drawing of an analogous specimen, under the name *Fissurina dentata* (Foram. Monotal. Mess., pl. i. fig. 55).

Lagena marginata has been found at the most northerly points at which soundings have yet been taken (lat. 83° 19′ N.) and thence southward in every sea almost to the Antarctic Ice-barrier; and at every depth from the littoral zone down to 3125 fathoms.

Its earliest appearance, so far as at present known, is in the Chalk of the Island of Rügen. It recurs in the Eocene deposits of the Paris Basin (Terquem), in the Septaria-clays of Germany (Reuss), the *Clavulina-szabói* beds of Hungary (Hantken), the Salt-clay of Wieliczka (Reuss), the Miocene and Pliocene of Southern Italy and Sicily (Seguenza), and of the south-east of Spain (Parker and Jones), and in the Post-tertiary formations of England, Scotland, Ireland, and Italy (Shone, Robertson, &c.).

Lagena marginata, var. *semimarginata*, Reuss (Pl. LIX. figs. 17, 19).

Lagena marginata, var. *semimarginata*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 468;—Schlicht, 1870, Foram. Pietzpuhl, pl. iv. figs. 4–6, 10–12.

Lagena vulgaris, var. *marginata* (pars), Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 55, pl. xix. figs. 28, 29?

Amongst von Schlicht's illustrations of Tertiary Foraminifera are two *Lagenæ* closely resembling that from which the drawing (fig. 17) has been taken. The body of the shell is biconvex and surmounted by a long tubular neck, and the angle between the body and the neck, on the median line, is occupied by a thin lamelliform wing. To this variety the trivial name "*semimarginata*" is assigned by Reuss. The shells of recent specimens are frequently marked by conspicuously large perforations, and the same is observable in one of the original figures above referred to. The test is often, perhaps always, furnished with an entosolenian tube as well as the external neck.

This semi-marginate variety occurs off Prince Edward's Island, 50 to 150 fathoms; off Heard Island, 75 fathoms; and at three Stations in the South Atlantic, in mid-ocean, depth, 1900 fathoms, 2200 fathoms, and 2350 fathoms respectively.

Von Schlicht's examples were from the Septaria-clays of Pietzpuhl in North Germany.

Lagena siliqua, Rymer Jones (Pl. LIX. fig. 27).

Lagena vulgaris, var. *siliqua*, Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 61, pl. xix. fig. 49.
,, *samara*, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

The test of *Lagena siliqua* is elongate and compressed, broadest near the middle and tapering towards the ends, both of which are pointed. It consists of a central, circular, biconvex chamber, with a large peripheral wing, which is narrow at the sides but much developed at base and apex. Length, nearly $\frac{1}{20}$th inch (1·26 mm.).

This is a rare variety. The single Challenger specimen was found in company with *Lagena seminiformis* in mid-Atlantic, a little south of the equator, depth 2350 fathoms; that figured by Rymer Jones was from near the coast of Java, 1080 fathoms.

Lagena seminiformis, Schwager (Pl. LIX. figs. 28–30).

Miliola stiligera (?), Ehrenberg, 1854, Mikrogeologie, pl. xxxi. fig. 6.
Lagena seminiformis, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 208, pl. v. fig. 21.

Of this singular and beautiful species Dr. Schwager has only figured one, and that, judging from the deep-sea specimens, scarcely a typical example.

The body of the shell is circular and biconvex, surmounted by a long tubular neck; and the whole is surrounded by a broad laminar wing reaching to the oral end of the neck and extended at the base so as to form two points which are separated by a wide central depression. Specimens sometimes attain a length of nearly $\frac{1}{20}$th inch (1·26 mm.).

Under the name *Miliola stiligera*, Ehrenberg has introduced a fossil *Lagena* differing but little in general contour from some of the more elongate specimens of the present species; but the drawing is taken from an imperfect shell, and, owing to the method of observation pursued by the author, the characters are left somewhat obscure.

In the living state *Lagena seminiformis* is essentially a deep-water organism. Its distribution-list includes two Stations in the North Atlantic, 1000 fathoms and 1750 fathoms respectively; three in the South Atlantic, 1425 to 2350 fathoms; four in the South Pacific, 1375 to 2075 fathoms; and one in the North Pacific, 1850 fathoms.

The specimens described by Schwager were Upper Pliocene fossils from Kar Nicobar; that figured in the "Mikrogeologie" was from the Chalk of Volsk in Russia.

Lagena lagenoides, Williamson, sp. (Pl. LX. figs. 6, 7, 9, 12–14).

Entosolenia marginata, var. *lagenoides*, Williamson, 1858, Rec. For. Gt. Br., p. 11, pl. i. figs. 25, 26.
Lagena lagenoides, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 324, pl. ii. figs. 27, 28.
Fissurina reussiana, Seguenza, 1862, Foram. Monotal. Mess., p. 69, pl. ii. fig. 40.
„ *radiata*, Id. Ibid. p. 70, pl. ii. fig. 42.
Lagena tubulifera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

Amended characters:—Test oval or pyriform, biconvex; with long ectosolenian neck, which is sometimes continued into the cavity of the shell as an entosolenian tube; periphery furnished with a laminar wing of variable width, traversed by conspicuous, parallel or radiating tubuli. Length of large specimens nearly $\frac{1}{50}$th inch (0·5 mm.).

At first sight it is difficult to identify the deep-sea examples of this form, which for the most part are characterised by a broad and conspicuously tubulated wing, by reference to Williamson's modest drawings; neither does his accompanying description, which misses the salient features of the fully developed shell, afford much assistance. The variability of the wing both in width and thickness, as well as in the character of the tubulation, is illustrated to some extent by the figures in Pl. LX.

Minute specimens of *Lagena lagenoides* are not unfrequent on the shores of the British Islands, but it is most familiar as a mid-Atlantic species. Notes have been kept of its occurrence at five Stations in the North Atlantic, the depths ranging from 767 fathoms to 2740 fathoms, and at five Stations in the South Atlantic, 675 to 1990 fathoms. It has also been found in comparatively shallow water at three Stations in the South Pacific, 38 to 410 fathoms.

It is figured by Seguenza from specimens obtained in the Miocene deposits of Sicily, and has been found by Mr. Wright in the Post-tertiary deposits of the north-east of Ireland, but is not otherwise known as a fossil species.

Lagena lagenoides, var. *tenuistriata*, H. B. Brady (Pl. LX. figs. 11, 15, 16).

Lagena tubulifera, var. *tenuistriata*, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

Morphological characters similar to those of *Lagena lagenoides;* the body of the shell ornamented with delicate longitudinal striæ.

The striate variety of the last-described species occurs in the North Atlantic, south of the Rockall Bank, 630 fathoms; at one Station in the South Atlantic, mid-ocean, 1990 fathoms; and elsewhere, in company with the typical form.

Lagena formosa, Schwager (Pl. LX. figs. 10, 18–20, and ♂ ?, 17 ?).

Lagena formosa (pars), Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 207, pl. iv. figs. 19*a*, 19*d*.

Under the name *Lagena formosa*, Dr. Schwager has figured two somewhat distinct forms, the first of which may be accepted as the specific type. With this the drawings now furnished agree in all respects, except that in some cases the outline is proportionately longer and narrower.

The body of the shell is oval, elongate-oval, or pyriform, and tapers to a narrow tubular neck of considerable length; the periphery is surrounded by a wing of moderate width, generally emarginate at the base in adult shells, and more or less tubulated. Immediately surrounding the body, on the line of union with the wing, is a raised edge or border, marked with a sort of punctate ornament. Specimens frequently attain a length of $\frac{1}{25}$th inch (1 mm.) or more.

Setting aside two Stations in the Southern Ocean, at which one or two small or broken specimens have been obtained at depths of 50 to 150 fathoms, *Lagena formosa*, so far as can be learnt from the Challenger collections, is essentially a deep-water Foraminifer. Its presence has been noted at four Stations in the North Atlantic, 2435 to 2750 fathoms; at two in the South Atlantic, 1035 and 1425 fathoms; at one in the Southern Ocean, near the Antarctic Ice-barrier, 1300 fathoms; at five in the South Pacific, 1075 to 2350; and at two in the North Pacific, 1850 and 2575 fathoms respectively.

The species occurs as an Upper Pliocene fossil in the Island of Kar Nicobar.

Lagena formosa, var. *favosa*, nov. (Pl. LX. fig. 21).

This is a mere sub-varietal form, differing from the type in having two or three rows of reticulated ornament between the body of the test and the peripheral wing.

It is comparatively rare, but occurs in company with allied forms at a few localities, notably at Station 224, in the western part of the North Pacific, 1850 fathoms.

Lagena formosa, var. *comata*, nov. (Pl. LX. fig. 22).

This, again, is a sub-varietal modification,—characterised by the striate surface of the body of the shell. The intermediate border and the base of the neck are more or less reticulated.

Found with the foregoing variety in the North Pacific, 1850 fathoms.

Lagena formosa, var. *brevis*, nov. (Pl. CXIV. fig. 10, *a.b.*).

The test of var. *brevis* is relatively shorter and broader than that of the type; the body is small, oval in outline, and flattened, and the surface punctate; the intermediate border is transversely ribbed, and the wing more or less tubulated.

It is a beautifully decorated form, only found hitherto in coral-sand dredged off Raine Island, 155 fathoms.

Lagena squamoso-marginata, Parker and Jones (Pl. LX. fig. 24).

Lagena squamoso-marginata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 356, pl. xviii. fig. 2, *a.b.*

The test of *Lagena squamoso-marginata* is pyriform in outline, compressed and biconvex, the peripheral edge acute or carinate, and the surface hexagonally areolated

The species occurs at three points in the North Atlantic, the depths varying from 422 fathoms to 816 fathoms; on the Australian coral-reefs; and on the west coast of New Zealand, 1100 fathoms.

In the fossil state it has been found in the Middle Tertiaries of San Domingo (Parker and Jones), and in the Pliocene of Southern Italy (Seguenza).

Lagena squamoso-alata, H. B. Brady (Pl. LX. fig. 23).

Lagena squamoso-alata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

The test of this variety resembles that of *Lagena squamoso-marginata*, with the addition of a raised reticulated border, and a broad tapering wing with radiate markings.

Lagena squamoso-alata has been met with at three "Porcupine" Stations in the North Atlantic, west of Ireland, at depths of 173 fathoms, 630 fathoms, and 1445 fathoms respectively.

Lagena radiato-marginata, Parker and Jones (Pl. LXI. figs. 8, 9).

Lagena radiato-marginata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 355, pl. xviii. fig. 3, *a.b.*

This elegant species differs from most of its congeners in the nature of the ornamental markings of the test. In the original description (*loc. cit.*) it is stated that "the pseudopodia begin to enter the shell-wall near the centre, and then burrow radially to escape near the margin; the shell-surface being perfectly smooth and as polished as glass." The glassy smoothness of the exterior is generally a conspicuous feature of the shell, but in some instances the striæ have more the appearance of corrugations of the inner surface of the wall than of actual tubulation.

The Challenger collections yield specimens of *Lagena radiato-marginata* from Nares Harbour, Admiralty Islands, 37 fathoms, and from Raine Island, Torres Strait, 155 fathoms; and those described by Parker and Jones were from the Australian coral-reefs.

As a fossil it has been found by the above-mentioned authors, in the Middle Tertiary formations of the neighbourhood of Bordeaux.

Lagena wrightiana, H. B. Brady (Pl. LXI. figs. 6, 7).

Lagena wrightiana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 62.

Test oval, flattened; margin thin, furnished with a narrow peripheral border; surface-ornament consisting of a number of longitudinal, parallel, excavated grooves, covering the two faces of the test except the central portions, which are smooth. Aperture encircled by a stout, sessile, phialine lip, entosolenian. Length, $\frac{1}{90}$th inch (0·28 mm.).

This pretty variety, named after Mr. Joseph Wright, F.G.S., of Belfast, to whose courtesy I am indebted for many notes especially on matters connected with the present genus, was found in anchor mud from Nares Harbour, Admiralty Islands, 37 fathoms, and has not hitherto been observed elsewhere.

Lagena schulzeana, H. B. Brady (Pl. LXI. fig. 10).

Lagena schulzeana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 62.

Test oval, compressed, subcarinate; faces flattened; neck wide and very short, finished with a rounded lip. Surface-ornament consisting of a number of more or less regular transverse bars, horizontal in the middle and bent downwards at an angle, near the periphery. Length, $\frac{1}{65}$th inch (0·4 mm.).

There are several varieties of *Lagena* in which the surface decoration consists of raised longitudinal lines connected by a system of transverse bands; but *Lagena schulzeana* is, so far as I am aware, the only form in which the transverse ornament appears by itself.

The habitat of the species is—off Raine Island, Torres Strait, 155 fathoms.

Lagena trigono-marginata, Parker and Jones (Pl. LXI. figs. 12, 13).

Trigonulina globosa, Seguenza, 1862, Foram. Monotal. Mess., p. 75, pl. ii. figs. 60–62.
Lagena trigono-marginata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 348, pl. xviii. fig. 1, *a. b.*
Ovolina trigonula, Terquem, 1866, Foram. du Lias, 6ième. Mém., p. 473, pl. xix. fig. 2, *a.b.*
Lagena trigono-marginata, Robertson, 1875 (in G. S. Brady and Robertson's Dredging Report), Report Brit. Assoc. p. 190.
„ „ Wright, 1877, Proc. Belfast Nat. Field Club, 1876–7, App., p. 104, pl. iv. fig. 8, *a.b.*

In *Lagena trigono-marginata* the three salient angles of the test are emphasized by a marginal beading with acute or subcarinate edge. The normal form is ovate or pyri-

form, as represented in fig. 12; rarely, the shell has a more or less truncate base, as in fig. 13.

Lagena trigono-marginata has only been met with at two Challenger Stations, namely:—in the North Pacific, at a depth of 2300 fathoms; and off Raine Island, Torres Straits, 155 fathoms. It occurs, however, in two of the "Porcupine" dredgings from the North Atlantic, off the west coast of Ireland, 90 fathoms and 1360 fathoms respectively; also in Dublin Bay (Balkwill and Wright), in the estuary of the Dee (Siddall), and on the coast of Yorkshire (Robertson).

It has been obtained from the Eocene deposits of Grignon, France (Parker and Jones), and from the Post-tertiary beds of the north-east of Ireland (Wright). Terquem (*loc. cit.*) figures a Liassic specimen of greater proportionate length, but not otherwise distinguishable from the normal form.

Lagena trigono-ornata, H. B. Brady (Pl. LXI. fig. 14).

Lagena trigono-ornata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 62.

Test oval or pyriform, trifacial, with three equidistant longitudinal carinæ; the carinæ consisting of thick bands of cellulated shell-substance reticulated externally Length, $\frac{1}{36}$th inch (0·7 mm.).

This variety resembles *Lagena trigono-marginata* in general conformation, but the peripheral keels, instead of being simple angular projections, are much thickened, and present a honeycombed structure.

The figured shell is from the north coast of Papua, near the equator, 1070 fathoms. Specimens with somewhat similar characters have been obtained from the estuary of the Dee (Mrs. Shone), from Dublin Bay (Balkwill and Wright), and, in the sub-fossil condition, from the estuarine clay of Limavady, in the north-east of Ireland (Wright).

Lagena quadrangularis, n. sp. (Pl. CXIV. fig. 11, *a.b.*).

Test elongate, compressed, quadrangular in transverse section; inferior end rounded, sometimes mucronate; superior end tapering and terminating in a short apertural neck; lateral edges parallel; angles acute, subcarinate. Length, $\frac{1}{70}$th inch (0·36 mm.).

This is a scarce variety, differing from the *Tetragonulina prima* of Seguenza, in its comparatively flattened contour and the subcarinate condition of the salient angles.

Its occurrence, so far as at present known, is limited to a single locality,—off Raine Island, Torres Strait, 155 fathoms.

Lagena quinquelatera, H. B. Brady (Pl. LXI. figs. 15, 16).

Lagena quinquelatera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 60.

Test elongate, compressed equally on five sides; broadest below the middle, tapering gradually to a point at the oral extremity; inferior end obtuse or rounded, sometimes apiculate; peripheral angles sharp or carinate; surface smooth or very faintly striate; aperture ectosolenian. Length, about $\frac{1}{70}$th inch (0·36 mm.).

This is a symmetrical five-sided modification of *Lagena lævis*, with a short tapering neck.

It occurs in the South Pacific, north of the Society Islands, at a depth of 2350 fathoms, and in the Southern Ocean, off Prince Edward's Island, 50 to 150 fathoms.

Lagena orbignyana, Seguenza, sp. (Pl. LIX. figs. 1, 18, 24–26; winged variety, fig. 20).

Entosolenia marginata (pars), Williamson, 1858, Rec. For. Gt. Br., p. 9, pl. i. figs. 19, 20.
Fissurina orbignyana, Seguenza, 1862, Foram. Monotal. Mess., p. 66, pl. ii. figs. 25, 26.
„ *romettensis*, Id. Ibid. p. 66, pl. ii. fig. 24.
Lagena tricincta, Gümbel, 1868, Abh. d. k. bayer. Ak. Wiss., II. Cl., vol. x. p. 606, pl. i. fig. 8, *a.b.*
Fissurina marginata, var. *tricarinata*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 468, No. 19*a*. — Schlicht, 1870, Foram. Pietzpuhl, pl. iv. figs. 1–3 (ectosolenian form).
„ *tricincta*, Terquem, 1883, Mém Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 30, pl. i. fig. 19, *a.b.*
„ *tricarinata*, Id. Ibid. p. 31, pl. i. figs. 25–28.

Some confusion has existed with respect to the compressed and carinate varieties of *Lagena*, which appears to be due, in part at any rate, to Williamson's illustrations of *Entosolenia marginata*.

The original drawings of *Lagena marginata* (Test. Min., pl. i. fig. 7) represent a compressed pyriform shell with thin somewhat carinate periphery, not unlike fig. 21 of Williamson's Monograph, or Pl. LIX. fig. 22 of the present Report. The external orifice of such forms is generally Fissurine.

There is, however, a very distinct variety in which the convex body of the shell, on both faces, is bordered by a raised edge in addition to the peripheral keel, and when this feature is conspicuously developed, the test appears to have three nearly parallel carinæ, of which the central one is widest. The peculiar contour of the test is best seen in the end view (fig. 24, *b.*, or 26, *b.*). Williamson's figures (19, 20) manifestly pertain to this variety rather than to the true "*marginata*." They represent excellently the small specimens common in the British seas, but are wanting in the strongly marked features displayed by those inhabiting deeper water.

Of the numerous names which have been applied to the "tricarinate" as distinct from the "marginate" form, one of those proposed by Seguenza takes precedence.

A variety, closely allied to that under consideration, has been described by Seguenza under the name *Fissurina marginata* (*op. cit.*, p. 66, pl. ii. figs. 27, 28) and by Terquem as *Fissurina bicarinata* (Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 31, pl. i. fig. 24), the test of which presents a double peripheral keel, the margin being divided on the median line by a deep furrow.

The geographical distribution of *Lagena orbignyana* is world-wide, and its bathymetrical range extends from the shallowest bottoms to depths of 3000 fathoms or even more.

Its range as a fossil extends back as far as the commencement of the Tertiary epoch. It has been observed in the Eocene of the Paris Basin (Terquem), and of the Bavarian Alps (Gümbel); in the Septaria-clays of Germany (Reuss, Schlicht), in the Miocene of Calabria and Sicily (Seguenza), and in the Post-tertiary beds of Ireland (Wright).

Lagena castrensis, Schwager (Pl. LX. figs. 1, 2, and 3 ?).

Lagena castrensis, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 208, pl. v. fig. 22.
Lagena vulgaris, var. *helophoro-marginata*, Ry. Jones, 1872, Trans. Linn. Soc. Lond., vol. xxx. p. 61, pl. xix. fig. 48.

This is an interesting variety of *Lagena orbignyana*, excellently figured by Dr. Schwager, distinguished by the peculiar surface-ornament of large exogenous beads, irregularly scattered over the lateral faces of the test.

The Challenger specimens are from four Stations, as follows:—off East Moncœur Island, Bass Strait, 38 fathoms; off Raine Island, Torres Strait, 155 fathoms; off Amboyna, 15 to 20 fathoms; and the *Hyalonema*-ground, south of Japan, 345 fathoms. It occurs also in the Java Seas, 1080 fathoms (Rymer Jones), and small examples have been found on the Irish coast, 45 to 50 fathoms (Balkwill and Wright).

The fossil specimens which formed the subject of the original description were from the Pliocene deposits of Kar Nicobar.

Lagena clathrata, n. sp. (Pl. LX. fig. 4).

Test nearly circular, tapering slightly towards the oral end, compressed; peripheral margin extended into a thin flat wing or carina, with an additional projecting keel or ridge on each side bordering the chamber. The body of the test biconvex, ornamented externally with a series of regular, parallel, longitudinal costæ. Aperture pouting; oval, or fissural. Longer diameter, $\frac{1}{70}$th inch (0·36 mm.).

In the general contour of the test and the arrangement of the peripheral keels, *Lagena clathrata* resembles *Lagena orbignyana*, but the lateral faces are decorated with stout, parallel, longitudinal costæ. Its nearest ally is *Lagena pulchella*, Brady (Ann.

and Mag. Nat. Hist., ser. 4, vol. vi. p. 294, pl. xii. fig. 1), the shell of which takes a similar form, but has a superficial ornament of irregular, more or less branching or reticulated, longitudinal ribs.

In the Challenger gatherings *Lagena clathrata* occurs only in sands dredged near the islands to the south-west of New Guinea, notably off the Ki Islands, 580 fathoms, and off Aru Island, 800 fathoms; in these two localities it is tolerably abundant. Messrs Balkwill and Millett have a similar form, in which, however, the peculiarities are less distinctly marked, from the shore-sands of Galway.

Lagena quadricostulata, Reuss (Pl. LIX. fig. 15, and fig. 7 ?).

Lagena quadricostulata, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 469.—Schlicht, 1870, Foram. Pietzpuhl, pl. iv. figs. 25–30.

The test of *Lagena quadricostulata* is pyriform and more or less compressed, the margin obtuse or rounded, the base frequently mucronate, and the aperture entosolenian; the surface bears four arched costæ, two on each face of the test, near the lateral margins and parallel to them. The costæ are thickest near the middle, and taper away towards the ends.

Reuss remarks that the test of this species presents intermediate characters, and appears equally related to *Lagena* and *Fissurina*, the form and general aspect being *Fissurina*-like, whilst the external orifice is circular as in the typical *Lagenæ*.

The best recent specimens that have been met with were dredged in Balfour Bay, Kerguelen Island, at depths of 20 to 50 fathoms, and off Sydney, 410 fathoms.

Von Schlicht's specimens, described by Reuss, were from the Septaria-clay of Pietzpuhl, in North Germany.

Lagena fimbriata, H. B. Brady (Pl. LX. figs. 26–28).

Lagena fimbriata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

Test pyriform or flask-shaped, broad at the base, compressed; ento- or ecto-solenian; furnished with a deep vertical wing, encircling the oval base; the wing traversed by parallel tubuli, and sometimes fringed at the free margin. Length, $\frac{1}{60}$th inch (0·42 mm.).

The general contour of the test of this species varies a good deal, as shown by the three figured examples, but the oval wing surrounding the base is in all cases a conspicuous feature.

Lagena fimbriata is a rare variety, and affects very deep water. It has been noticed at three Stations in the North Atlantic, at one in the Southern Ocean, at three in the South Pacific, and at one in the North Pacific. Of these two are respectively at 580

fathoms and 620 fathoms, the remaining six at depths of 2300 fathoms or more. I learn from my friend Mr. F. W. Millett that specimens have been found cast up on the coast of Galway.

Lagena auriculata, H. B. Brady (Pl. LX. figs. 29, 33).

Lagena auriculata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

Test pyriform compressed, ento- or ecto-solenian; bearing on each side, near the base, a loop-shaped laminar extension of the wall enclosing a portion of the lateral margin. Margin sometimes carinate or alate, the keel or wing dividing near the base on each side so as to form similar loops; when broad, the wing is often conspicuously tubulated. Length, $\frac{1}{60}$th inch (0·42 mm.).

Lagena auriculata is closely allied to the species last described, *Lagena fimbriata*, but in the latter the entire base of the test is surrounded by a vertical wing, whilst in the present form two smaller areas, one at each lateral margin near the base, are so enclosed.

Lagena auriculata is found in the North and South Atlantic and in the South Pacific, at depths ranging from 1370 to 2740 fathoms. It has been noticed in one locality, off Gomera, Canaries, at less depth, namely, 620 fathoms, but the specimens were small and poorly developed.

Lagena auriculata, var. *costata*, H. B. Brady (Pl. LX. fig. 38).

Lagena auriculata, var. *costata*, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

This variety partakes of the general characters of the type, but the body of the test is costate, resembling *Lagena sulcata*, and carinate.

It has been dredged in the Low Archipelago, 2350 fathoms, and in the deep area of the North Pacific, 2300 fathoms.

Lagena alveolata, n. sp. (Pl. LX. figs. 30, 32).

Test pyriform compressed, lateral edges obtuse or rounded; base broad and round in outline, rarely mucronate; furnished with a median and two lateral carinæ, which unite so as to form two loops on each side of the test, usually separated by a central depression. Length, $\frac{1}{50}$th inch (0·5 mm.).

This belongs to the same group of forms as *Lagena auriculata*, but differs from that species in having the spaces enclosed by the carinæ divided by the central keel, so as to form four loops instead of two.

Lagena alveolata is only found in deep water. It occurs in the North Atlantic, 2750

fathoms; in the South Atlantic, 2200 fathoms, and 2350 fathoms; in the Southern Ocean, 2600 fathoms; in the South Pacific; and in the North Pacific, 2300 fathoms.

Lagena alveolata, var. *caudigera*, nov. (Pl. LX. fig. 25).

General conformation of the test similar to that of *Lagena alveolata*, but somewhat broader in outline; armed at the base with two long spines springing from the median line; surface near the base ornamented with faint beaded lines.

The caudate variety of the species has only been observed in the South Pacific, south-west of Juan Fernandez, 1825 fathoms.

Lagena alveolata, var. *substriata*, H. B. Brady (Pl. LX. fig. 34).

Lagena auriculata, var. *substriata*, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 61.

General characters the same as those of *Lagena alveolata;* the surface of the test more or less costate or striate, especially near the base and apex.

Found at Station 146, Southern Ocean, 1375 fathoms.

Sub-family 2. Nodosarinæ.

Nodosaria, Lamarck.

"Cornu Hammonis," Plancus [1739].
Orthocera, *Orthoceras*/ seu *Orthoceratium*, pars, Gaultieri [1742], Soldani, Batsch, Lamarck, Defrance, Blainville, Fleming, Brown.
Nautilus, pars, Linné [1767], Martini, Batsch, Montagu, Maton and Rackett, Dillwyn, Pennant, &c.
Glandiolus, Montfort [1808].
Nodosaria, Lamarck [1816], Defrance, Blainville, d'Orbigny, Ehrenberg, Roemer, Cornuel, Reuss, Bornemann, Parker and Jones, Egger, Williamson, Carpenter, Karrer, &c.
Glandulina, d'Orbigny [1826], Reuss, Alth, Bornemann, Neugeboren, Costa, Egger, Terquem, Carpenter, Seguenza, Brady, Stache, &c.—(*Psecadium*, Reuss, Neugeboren, Karrer, Seguenza.—*Atractolina*, pars, Schlicht).
Dentalina, d'Orbigny [1826], Czjzek, Reuss, Cornuel, Alth, Bailey, Bornemann, Costa, Egger, Williamson, Terquem, Gümbel, Schwager, &c.
Encorycium, Ehrenberg [1859].
Nodosarina, pars, Parker and Jones [1859].
Frondicularia, pars, Berthelin [1879].

The typically constructed test of the genus *Nodosaria* consists of a series of chambers united in a straight or curved line, with the aperture at the centre of the terminal segment.

In the majority of cases the segments are small at the commencement and become

successively larger as the test approaches completion, but no general rule can be laid down in this respect. Sometimes the increase in size is confined to the earlier chambers, and those subsequently formed become gradually smaller, so that the shell is widest near the middle; occasionally the segments preserve a uniform diameter from first to last; and not unfrequently the initial segment is larger than those immediately succeeding it. The primordial end of the test is often mucronate.

The segments are attached end to end, in single series, and the general contour of the test depends to a great degree on the extent to which the adjoining chambers are in contact with each other. The shape of the individual segments may be cylindrical, inflated, pyriform, fusiform, elliptical, or globular; and they may either be combined like a row of beads with thin connecting stolons; or more closely, with external depressions of greater or less depth marking the septal planes; or so as to form a compact cylinder with the sutures indicated only by fine lines; or lastly, the segments may be inequilateral and the sutures oblique.

The aperture is terminal, and is usually situated in a nipple-shaped projection, or in a more or less produced neck; but sometimes it is flush with the surface of the final segment, and in rare cases it is inverted as in the entosolenian *Lagenæ*. It takes the form either of a simple rounded orifice, with or without an everted lip, or of a number of radiating fissures; and when simple is frequently surrounded by a radiate corona of superficial grooves or raised lines.

The exterior of the test is either smooth or ornamented by the exogenous thickening of the wall in various ways. Longitudinal striæ, continuous or interrupted costæ, tubercles, or spines, are the more common varieties of surface-ornament. In addition to these, the septal lines are sometimes limbate or embossed, and the tubular neck of certain species is often decorated with raised annulated or spiral bands of shelly deposit.

The genus *Nodosaria* was divided by d'Orbigny into five sub-genera:—I. *Glandulina;* II. *Nodosaria,* proper; III. *Dentalina;* IV. *Orthocerina;* V. *Mucronina.*[1] Of these *Mucronina* contained only a single species, differing in no important particular from *Lingulina*, and was subsequently abandoned by the author. The name *Orthocerina* was employed for a mixed group, the Nodosarine members of which are now included in Reuss's genus *Rhabdogonium*, for reasons which will appear on a later page. Of the rest, the most that can be said is that the term *Dentalina* has been used to distinguish the curved varieties, and *Glandulina* the short varieties of the genus. Employed in this way the terms are sometimes convenient, but in any stricter or more definite sense they have no zoological value.

The immediate allies of *Nodosaria* are found in the genera *Frondicularia*, *Lingulina*, and *Vaginulina*, which represent respectively the compressed forms of the short, normal, and obliquely-septate varieties of the type.

[1] *Ann. Sci. Nat.*, 1826, vol. vii. pp. 252–256.

In the living condition the genus has been found at almost every latitude hitherto explored, and it has a bathymetrical range extending to depths of 2400 fathoms or more. As a fossil it furnishes some of the oldest known Foraminifera, having been identified in beds of Lower Silurian age. There is some doubt as to its presence in the Carboniferous rocks, but in those of the Permian system and thenceforward it is one of the commonest generic types, and one of the most widely distributed.

The literature of the genus is correspondingly extensive, and it affords an example of reckless species-making without a parallel even amongst the Foraminifera. One memoir, however, is worthy of mention as an exception to the mode of treatment generally pursued, namely, the admirable monograph of Prof. Silvestri,[1] in which a commendable and on the whole successful effort is made to reduce a varied series of forms into reasonable "specific" groups; and it is a matter for regret that the scheme of this work was not extended, so as to furnish a complete synopsis of the genus. Considerable assistance in the identification of specimens may be derived from von Schlicht's illustrations of Tertiary Foraminifera[2] and Prof. Reuss's notes thereupon;[3] but notwithstanding the diminished number of species recognised by the last-named author in his maturer years, the nomenclature would bear further reduction without loss to science.

Nodosaria lævigata, d'Orbigny (Pl. LXI. figs. 17–22, 32).

A. Typical form,—tapering to a point, or apiculate, at the primordial end.

Nodosaria (Glandulina) lævigata, d'Orbigny, Pl. LXI. figs. 20–22.

"Cornu Hammonis erectum globosius," Plancus, 1739, Conch. Min., p. 16, pl. xiii. fig. 1.
Nodosaria (Glandulina) lævigata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 252, pl. x. figs. 1–3.
Glandulina lævigata, Id. 1846, For. Foss. Vien., p. 29, pl. i. figs. 4, 5.
„ *ovula*, Id. Ibid. p. 29, pl. i. figs. 6, 7.
„ *pygmæa*, Reuss, 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 22, pl. ii. fig. 3.
„ *inflata*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 320, pl. xii. figs. 6, 7.
„ *lævigata*, Id. Ibid. p. 320, pl. xii. fig. 8.
„ *elongata*, Id. Ibid. p. 321, pl. xii. fig. 9.
„ *acuminata*, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 125, pl. xi. fig. 19.
„ *inflata*, Id. Ibid. p. 126, pl. xi. fig. 21.
„ *apiculata*, Id. Ibid. p. 127, pl. xi. fig. 22.
„ *pyrula*, Id. Ibid. p. 370, pl. xxvii. fig. 26.
„ *abbreviata*, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 68, pl. i. fig. 1.
„ *lævigata*, Id. Ibid. p. 67, pl. i. figs. 3, 4.
„ *elliptica*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 47, pl. iii. figs. 29–31.
„ *globulus*, Id. Ibid. p. 66, pl. viii. figs. 94, 95.

[1] Le Nodosarie fossili nel terreno subapennino Italiano e viventi nei mari d'Italia.—Monografia del Prof. Orazio Silvestri, Catania, 1872.

[2] Die Foraminiferen des Septarienthones von Pietzpuhl, *Berlin*, 1870.
Sitzungsb. d. k. Ak. Wiss. Wien., 1870, vol. lxii. p. 455.

Glandulina annulata, Stache, 1864, Novara-Exped., geol. Theil, vol. i., Paläont., p. 184, pl. xxii. fig. 6.
„ *subovata*, Id. Ibid. p. 185, pl. xxii. fig. 7.
„ *napæformis*, Id. Ibid. p. 186, pl. xxii. fig. 8.
„ *symmetrica*, Id. Ibid. p. 187, pl. xxii. fig. 9.
Nodosaria (*Gl.*) *lævigata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 340, pl. xiii. fig. 1.
Glandulina gracilis, Reuss, 1865, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 137, pl. ii. figs. 25–27.
„ *lævigata*, var. *inflata*, Id. Ibid. p. 136, pl. ii. figs. 29–31.
„ *cuneiformis*, Terquem, 1866, Foram. du Lias, 6ième Mém., p. 478, pl. xix. fig. 7.
„ *obconica*, Reuss, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 104, pl. i. fig. 7.
„ *turbiniformis*, Terquem, 1870, Foram. du Syst. Oolith., 3ième Mém, p. 240, pl. xxv. fig. 9.

a. **Asymmetrical tapering specimens, with more or less oblique sutures.**

Glandulina elongata, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 128, pl. xi. fig. 23.
„ *adunca*, Id. Ibid. p. 128, pl. xi. fig. 24.
Psecadium simplex, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 99, pl. v. fig. 13.
„ *elongatum*, Reuss, 1858, Zeitschr. d. deutsch. geol. Gesell., vol. x. p. 437, No. 1.
„ *subovatum*, Karrer, 1864, Sitzungsb. d. k. Ak. Wiss. Wien, vol. l. p. 707, pl. i. fig. 7.
Atractolina, sp., Schlicht, 1870, Foram. Pietzpuhl, p. 69, pl. xxv. figs. 1–10.
Psecadium acuminatum, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 470, No. 1.

B. **Oval variety with rounded base.**

Nodosaria (*Gl.*) *rotundata*, Reuss, Pl. LXI. figs. 17–19.

Glandulina rotundata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 366, pl. xlvi. fig. 2.
„ *ovalis*, Alth, 1850, Haidinger's Naturw. Abhandl., vol. iii. p. 270, pl. xiii. fig. 31.
„ *concinna*, Reuss, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 263, pl. viii. fig. 1.
„ *obtusa*, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 126, pl. xi. fig. 20.
„ *punctata*, Egger, 1857, Neues Jahrb. für Min. &c., p. 305, pl. xv. figs. 32, 33.
„ *obtusissima*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 66, pl. viii. figs. 92, 93.
Nodosaria radicula (pars), Parker and Jones, 1865, Phil. Trans., vol. clv. p. 341, pl. xiii. figs. 2, 3, &c.
Glandulina pygmea, Terquem, 1866, Foram. du Lias, 6ième mém., p. 478, pl. xix. fig. 6.
„ *oviformis*, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i. Mém. III., p. 12, pl. i. figs. 1, 2.
„ *nummularia*, Gümbel, 1868, Abhandl. d. k. bayer. Ak. Wiss., II. Cl., vol. x. p. 628, pl. i. fig. 50.
„ *undulata*, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lviii. p. 165, pl. iv. fig. 2.
„ *parallela*, Marsson, 1878, Mittheil. naturw. Vereine v. Neu-Vorpom. u. Rügen., Jahrg. x. p. 124, pl. i. fig. 4.

b. **Asymmetrical specimens with rounded base, and more or less oblique sutures.**

Psecadium ellipticum, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 99, pl. v. fig. 14.
„ *ovatum*, Seguenza, 1880, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 139, pl. xiii. fig. 8.

C. Elongate cylindrical variety.

Nodosaria (Gl.) æqualis, Reuss, Pl. LXI. fig. 32.

Glandulina inæqualis, Egger, 1857, Neues Jahrb. für Min. &c., p. 305, pl. xv. figs. 26, 27.
„ *candela*, Id. Ibid. p. 304, pl. xv. figs. 28, 29.
„ *æqualis*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 48, pl. iii. fig. 28.
„ *lævigata*, var. *æqualis*, Reuss, 1870, Ibid. vol. lxii. p. 478;—Schlicht, 1870, Foram. Pietzpuhl, pl. vi. figs. 21, 22, 24.
„ „ var. *subcylindrica*, Reuss, 1870, Ibid. p. 477;—Schlicht, Ibid. pl. vi. fig. 5.

The typical *Nodosaria* (*Glandulina*) *lævigata* of d'Orbigny has a subovate test, circular in transverse section, broadest a little above the middle, tapering rapidly towards the oral end which is somewhat rounded, and more gradually towards the opposite extremity which is acutely pointed. The segments are six in number, and embracing, the latest occupying more than half the visible shell; and the sutures are marked externally by fine lines without the least superficial depression. This description applies to the author's own figure (Ann. Sci. Nat., vol. vii. pl. x. figs. 1-3); but the drawing in Soldani's "Testaceographia," which is referred by d'Orbigny to the same species (*loc. cit.*, p. 252), represents a three-chambered shell, broad and round in its oral aspect, obtuse and rounded at the initial end, with inflated segments and sunken sutures. These two drawings, taken in connection with Parker and Jones's figures (Phil. Trans., vol. clv. pl. xiii. figs. 1–7), illustrate to some extent the variability of the species and its relation to the other straight Nodosarians.

That d'Orbigny's original figure indicates the typical characters of a particular group of short *Nodosariæ* is evident from the fact that at localities in which such forms are rare the specimens are generally of the tapering sort with flush sutures; but more than this can scarcely be affirmed. On the other hand, in districts over which *Glandulinæ* abound, as for instance in the warm area of the Faröe Channel at a depth of 530 fathoms, or thereabouts, the specimens present a very wide range of external contour—subglobular, elliptical, tapering and pointed, or subcylindrical—without much apparent preference for one shape above another, and in such infinite gradations that it is impossible to reduce them to anything resembling true specific or varietal groups. This view had become familiar to me before I was aware that the Rev. A. M. Norman had arrived at the same conclusion from the study of the specimens obtained from his Norwegian dredgings. The extreme variability is not confined to the general contour of the test, but it affects to a greater or less degree all the minor characters of the type. It is equally difficult to draw any distinction between varieties with flush sutures, and those in which the segments are more or less inflated and the septal lines correspondingly depressed; indeed it would be quite possible to arrange a series of recent specimens exhibiting every stage of modification, from the tapering subfusiform shell with even sutures, represented by the d'Orbignian drawing, to the fully-developed *Nodosaria radicula* with nearly globular segments. In the absence of any valid distinctive character the term *Glandulina* becomes a mere name of con-

venience, applicable only in the subordinate sense in which it was at first employed, to a small and ill-defined section of the genus *Nodosaria*.

The Glanduline *Nodosariæ* may be roughly cast into three groups:—1, the tapering varieties, more or less resembling the type, *Nodosaria* (*Gl.*) *lævigata;* 2, the forms with oval outline and rounded base, of which *N.* (*Gl.*) *rotundata* is perhaps the earliest named example; 3, those with elongate subcylindrical shells, of which *N.* (*Gl.*) *æqualis* is the best illustration.

Prof. Reuss, in his valuable notes on von Schlicht's drawings of Tertiary Foraminifera,[1] published not long before his decease, states his conviction that the entire series must be accounted as one species, and suggests the following subdivision into varieties.

Glandulina lævigata, d'Orbigny.

a. Var. *typica*,—elliptical, inferior end pointed and with more or less curved sides.
b. Var. *elliptica*,—inferior end blunt or armed with a very short point, the lateral margins of the inferior portion not curved The somewhat elongate specimens form *Gl. elongata*, Bornem.
c. Var. *inflata*,—with large inflated final chamber.
d. Var. *subcylindracea*,—inferior end pointed, middle portion with parallel sides, cylindrical.
e. Var. *strobilus*,—elongate, gradually tapering towards the inferior end, blunt or with a rudimentary spine, the final segment occupying $\frac{2}{3}$ to $\frac{1}{3}$ of the entire length.
f. Var. *obtusissima*,—short, inferior end broad and rounded, the final chamber large and inflated.
g. Var. *globulus*,—almost spherical, inferior end abruptly pointed. Segments few in number, the last which is very large and rounded, forming the principal part of the test.
h. Var. *rotundata*,—like the last-mentioned, but very small, without the terminal point, rounded.
i. Var. *gracilis*,—thin and slender, inferior portion elongated and acutely pointed, not unfrequently with oblique septa. The "var. *emaciata*" belongs to the *Lagenæ*.
k. Var. *æqualis*,—more or less elongate and cylindrical; the passage-form to the cylindrical *Nodosariæ*.

In accordance with these definitions the figures in Pl. LXI. might be allotted as follows:—fig. 17, to Var. *rotundata* or *obtusissima;* figs. 18 and 19, and perhaps also fig. 20, to Var. *elliptica;* figs. 21 and 22 to the typical *lævigata*, and fig. 32 to Var. *æqualis;* but the laxity of the descriptive terms is sufficient indication of their slight zoological value.

In any large assemblage of *Glandulinæ* a few exceptional specimens will be found, having more or less oblique sutures, and as remarked by Reuss the slender modifications, such as Var. *gracilis*, are most subject to this peculiarity of growth. Sometimes the inequilateral development is sufficient to disturb the external symmetry of the test.

The condition referred to is precisely analogous to that of the curved or Dentaline *Nodosariæ;* it is brought about in the same way and has neither greater nor less morphological significance. Its importance, however, has been differently estimated by some writers, who have recognised in the mere one-sided growth of the shell the distinctive

[1] *Sitzungsb. d. k. Ak. Wiss. Wien*, vol. lxii. p. 478.

character of an independent genus, *Psecadium*, under which name the tapering and elliptical forms have each been parcelled out into a number of "species." Some of these anomalous specimens are interesting as connecting links with the ovate or subglobular varieties of *Cristellaria*, such as the *Cristellaria obvelata* of Reuss (Haidinger's Naturw. Abhandl., vol. iv. p. 33, pl. iii. fig. 11); but from any other point of view they are of very little consequence.

Nodosaria (*Gl.*) *lævigata*, in one form or other, is an almost cosmopolitan species, but it is especially abundant in the northern portion of the North Atlantic, the tapering and pointed varieties being most frequently met with. The area of distribution extends from lat. 79° 45′ N. in Smith Sound, to Magellans Strait, about lat. 53° S. The North Atlantic Stations show a range of depth from 50 to 1360 fathoms, those in the South Atlantic, from 350 to 1025 fathoms, the North Pacific, 7 to 95 fathoms, the South Pacific, 28 to 1070 fathoms, the Red Sea, 30 to 372 fathoms, and the Southern Ocean, one sounding only, 1375 fathoms. The rounded and oval forms are less widely distributed than the tapering varieties, though moderately common in the North Atlantic and the South Pacific. The subcylindrical modification with flush sutures has only been met with in the North Atlantic.

In the fossil condition the species makes its appearance in the Upper Trias (Jones and Parker), and is found in microzoic formations of almost every succeeding geological age.

Nodosaria (*Gl.*) *armata*, Reuss (Pl. LXIII. fig. 6).

Glandulina armata, Reuss, 1865, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 137, pl. ii. fig. 28.
„ „ Id. 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 477, No. 6;—Schlicht, 1870, Foram. Pietzpuhl, pl. vi. fig. 4.

The test of this species, as figured by v. Reuss and v. Schlicht, is nearly elliptical, slightly pointed at the primordial end, and with a somewhat protruding mammillate aperture. The final segment occupies about one-half of the visible shell, and its inferior margin is armed with a ring of equidistant pointed tubercles or bosses, which form a line round the middle of the test. The number of these tubercles is stated by Reuss to be nine or ten, but the figured specimens to which he refers appear to have nine and fourteen respectively, and they are set with extreme regularity. In the very few recent specimens that have come under my notice, the exostoses are neither so numerous nor so regular as depicted in these drawings.

Nodosaria (*Gl.*) *armata* has been obtained from one of the "Porcupine" dredgings in the North Atlantic, depth 725 fathoms.

So far as at present known its occurrence as a fossil is limited to the Septaria-clay of Pietzpuhl, in Germany.

Nodosaria radicula, Linné, sp. (Pl. LXI. figs. 28–31).

"Cornu Hammonis erectum," Plancus, 1739, Conch. Min., p. 14, pl. i. fig. 5.
Nautilus radicula, Linné, 1767, Syst. Nat., 12th Ed., p. 1164, 285;—1788, Ibid., 13th (Gmelin's) Ed., vol. i. pt. 6, p. 3373, No. 18.
,, ,, Montagu, 1803, Test. Brit., p. 197, pl. vi. fig. 4.
Nodosaria radicula, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 252, No. 3 ;—Modèle No. 1.
,, *geinitziana*, Neugeboren, 1852, Verhandl. u. Mitth. siebenb. Vereins f. Nat., Jahrg. iii. p. 37, pl. i. fig. 1.
,, *glandulinoides*, Id. Ibid. p. 37, pl. i. fig. 2.
,, *inconstans*, Id. Ibid. p. 38, pl. i. figs. 6, 7.
Glandulina tenuis, Bornemann, 1854, Liasformation, p. 31, pl. ii. fig. 3, *a.b.*
,, *major*, Id. Ibid. p. 31, pl. ii. fig. 4, *a.b.*
Nodosaria geinitzi, Reuss, 1854, Jahresb. d. Wetterauer Gesellsch., 1851–53, p. 77, fig. 12.
Glandulina elegans, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, p. 69, pl. i. fig. 5.
,, *reussi*, Id. Ibid. p. 69, pl. i. fig. 6.
Nodosaria beyrichi, Id. Ibid. p. 72, pl. i. figs. 7–9.
,, *incerta*, Id. Ibid. p. 72, pl. i. figs. 10, 11.
,, *kirkbyi*, Richter, 1861, Geinitz's Dyas, p. 121, pl. xx. fig. 30.
Glandulina conica, Terquem, 1862, Foram. du Lias, 2ième mém., p. 435, pl. v. fig. 10, *a.b.*
Nodosaria jonesi, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 89, pl. xii. fig. 6.
,, *claviformis*, Terquem, 1866, Foram. du Lias, 6ième mém., p. 477, pl. xix. figs. 17, 18.
,, *radicula*, Brady, 1867, Proc. Somerset. Arch. and Nat. Hist. Soc., vol. xiii. p. 106, pl. i. fig. 4.

The figures in the classical work of Plancus on which Linné based the present species are bold and characteristic. They indicate straight, tapering, Nodosarian shells, with four globular segments apiece and a central orifice on a somewhat produced neck, the surface of the shells being smooth and devoid of ornament. The chambers are more inflated and the sutures more depressed than those of the specimens from which the illustrations, Pl. LXI. figs. 28–31, are drawn, the latter showing some approach to the characters of *Nodosaria humilis*, Roemer (Verstein. norddeutsch. Kreid., 1841, pt. 2, p. 95, pl. xv. fig. 6). In these particulars many of the figures referred to in the synonymy accord much better with the original type.

Nodosaria radicula has a wide area of distribution. It is found in the arctic seas, and on the shores of Norway and of the British Islands ; in the North Atlantic, from shallow water to a depth of 1360 fathoms ; in the South Atlantic as deep as 2350 fathoms ; and in the South Pacific from 37 to 1100 fathoms ; and it also occurs in the Adriatic. It has not been observed in the North Pacific.

In the fossil state, the species has been identified in the Permian formations of England and Germany (Brady), in the Upper Trias of Derbyshire (Jones and Parker), in the Lias of various parts of England (Brady, Blake) in the Kimmeridge Clay (Blake), in the Chalk of the North of Ireland (Wright), and at almost every stage of the Tertiary series.

Nodosaria radicula, var. *annulata*, Terquem and Berthelin, var. (Pl. LXII. figs. 1, 2).

Glandulina annulata, Terquem and Berthelin, 1875, Mém. Soc. géol. France, sér. 2, vol. x. mém. III. p. 22, pl. i. fig. 25.

This variety only differs from the typical *Nodosaria radicula* in the decreasing size of one or two of the later segments, the test being widest near the middle instead of at the oral end.

Terquem and Berthelin figure two closely allied Nodosarians with the same peculiarity, under the names *Glandulina annulata* and *Dentalina mauritii* respectively (*loc. cit.*, figs. 25 and 28); the recent specimens present intermediate characters connecting the two. D'Orbigny gives us the same variety, but with a somewhat crescentiform aperture, in his *Lingulina rotundata* (For. Foss. Vien, p. 61, pl. ii. figs. 48–51).

The best living examples that have been met with are from Station 192, off the Ki Islands, 129 fathoms.

Nodosaria radicula, var. *ambigua*, Neugeboren (Pl. LXII. fig. 3, *a.b.*).

Nodosaria ambigua, Neugeboren, 1856, Denkschr, d. k. Ak. Wiss. Wien, vol. xii. p. 71, pl. i. figs. 13–16.

„ *tornata*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 223, pl. v. fig. 51.

This is a sub-varietal modification of *Nodosaria radicula*, with abnormally short segments.

Habitat, off the Ki Islands, 129 fathoms.

It occurs amongst other *Nodosariæ* as a Tertiary fossil.

Nodosaria simplex, Silvestri (Pl. LXII. figs. 4, 5, and fig. 6 ?).

Nodosaria simplex, Silvestri, 1872, Nodos. Foss. e Viv. d'Ital., p. 95, pl. xi. figs. 268–272.

Of the three drawings, fig. 4 corresponds in every particular with Silvestri's illustrations of *Nodosaria simplex* (*loc. cit.*), and fig. 5 resembles the same in a less degree; whilst fig. 6 bears more similarity to those of *Nodosaria antennula* (of Costa, not of d'Orbigny) furnished by the same author; but what may be the zoological value of either "species," the Challenger specimens are insufficient to show.

The recent examples are from—off the Ki Islands, 129 fathoms, and off the west coast of New Zealand, 275 fathoms.

Those figured by Silvestri and Costa were from the Subapennine Tertiaries of Italy.

Nodosaria calomorpha, Reuss (Pl. LXI. figs. 23–27).

Nodosaria calomorpha, Reuss, 1865, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 129, pl. i. figs. 15–19.
„ (*Dentalina*) *consobrina*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 342, pl. xvi. fig. 3.
„ *calomorpha*, Terrigi, 1880, Atti dell' Accad. Pont., ann. xxxiii. p. 178 pl. i. fig. 7.

This is a little insignificant species but very distinct nevertheless. The adult test has rarely more than three segments, often only two ; the primordial chamber is usually short and rounded, those subsequently formed more elongate and oval, and the aperture is often entosolenian. The average length of the test is about $\frac{1}{50}$th inch (0·5 mm.).

Owing to its small size and inconspicuous appearance, the species is easily overlooked. The following list of localities, though far from complete, indicates roughly its area of distribution :—North Atlantic, 1215 fathoms ; South Atlantic, mid-ocean, two soundings, 1990 fathoms and 2200 fathoms, and off the Falkland Islands, 6 fathoms ; off Kerguelen Island, 120 fathoms ; off the Ki Islands, two soundings, 129 fathoms and 580 fathoms ; and off the Philippine Islands, 95 fathoms.

Reuss's specimens were fossils from the Septaria-clay of Pietzpuhl, in North Germany.

Nodosaria pyrula, d'Orbigny (Pl. LXII. figs. 10–12).

"Orthoceras *Monile*," Soldani, 1798, Testaceographia, vol. ii. p. 35, pl. x. figs. *b.c.*
Nodosaria pyrula, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 253, No. 13.
„ *mariæ*, d'Orbigny, 1846, For. Foss. Vien., p. 33, pl. i. figs. 15, 16.
„ *stipitata*, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 366, pl. xlvi. fig. 4.
„ *haueriana*, Neugeboren, 1852, Verhandl. u. Mitth. siebenb. Vereins. f. Nat., Jahrg. iii. p. 39, pl. i. figs. 8, 9.
„ *lagenifera*, Id. Ibid. p. 39, pl. i. figs. 10–12.
„ *brukenthaliana*, Id. Ibid. p. 40, pl. i. figs. 13, 14.
Dentalina elongata, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 365, pl. xvi. fig. 19.
Nodosaria pyrula, Williamson, 1858, Rec. For. Gt. Br., p. 17, pl. ii. fig. 39.

A much attenuated variety, with pyriform or ovate segments, the distal ends of which form long narrow stoloniferous tubes. The curved modifications are only distinguished from *Nodosaria* (*D.*) *guttifera* (For. Foss. Vien., p. 49, pl. ii. figs. 11–13) by the somewhat more inflated segments and shorter stolons of the latter.

Nodosaria pyrula is a widely diffused species, but the number of specimens found in any one locality is generally small, a circumstance partly due to the fragile character of the shell. It is not uncommon in shallow water on the shores of the British Islands, Belgium, and France, and in the North Atlantic generally, at depths of less than 500 or 600 fathoms. It has not been noticed in the South Atlantic, but it occurs in the South Pacific, at depths of 38 to 620 fathoms ; in the North Pacific, from 95 to 345 fathoms ; and in the Mediterranean, from 40 to 250 fathoms.

As a fossil it has been found in the London Clay (Jones and Parker), in beds of Miocene age in Austria and elsewhere (d'Orbigny, Reuss, &c.), in the later Tertiaries of Italy (Soldani, d'Orbigny), and in the Post-tertiary deposits of Ireland (Wright), of Canada (Dawson), and of Norway (Crosskey and Robertson).

Nodosaria inflexa, Reuss (Pl. LXII. fig. 9).

Nodosaria inflexa, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 131, pl. ii. fig. 1.
„ „ Id. 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 472, No. 16;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxxviii. fig. 3.

This is a Dentaline variety with fusiform segments,—a transition form between *Nodosaria pyrula*, d'Orbigny, and *Dentalina guttifera*, d'Orbigny.

Its occurrence has been noted in the North Atlantic, and in the North and South Pacific, at various depths from 95 to 1400 fathoms ; and its distribution, whether recent or fossil, probably corresponds with that of the allied modifications of the type.

Nodosaria (*D.*) *farcimen*, Soldani, sp. (Pl. LXII. figs. 17, 18; woodcuts, fig. 13, *a.b.c.*).

" Orthoceras *Farcimen*," Soldani, 1791, Testaceographia, vol. i., pt. 2, p. 98, pl. cv. fig. *O*.
Nodosaria dentalina, Lamarck, 1822, Anim. sans Vert., vol. vii. p. 596, No. 2.
„ (*Dentalina*) *communis*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 254, No. 35.
Dentalina nodosa, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. p. 14, pl. i. figs. 6, 7.
„ *linearis*, Roemer, 1841, Verst. norddeutsch. Kreid., pt. ii. p. 95, pl. xv. fig. 5.
„ *legumen*, Reuss, 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 26, pl. ii. fig. 14.
„ *nodosa*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 164, pl. xii. fig. 8.
„ *subnodosa*, Terquem, 1858, Foram du Lias, 1ière mém., p. 600, pl. ii. fig. 7.
„ *strangulata*, Reuss, 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xl. p. 185, pl. ii. fig. 6.
„ *farcimen*, Reuss, 1861, Bullet. de l'Acad. roy. Belg., ser. 2, vol. xv. p. 146, pl. i. fig. 18.
Nodosaria (*Dentalina*) *laxa*, Reuss, 1865, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 132, pl. ii. figs. 2, 3.
„ *prægnans*, Reuss, 1865, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lii. p. 450, pl. i. fig. 4.
Dentalina fusiformis, Gümbel, 1868, Abhandl. d. k. bayer. Ak. Wiss., II. Cl., vol. x. p. 621, pl. i. fig. 35.
„ *linearis*, Id. Ibid. p. 622, pl. i. fig. 36.
„ *glandifera*, Id. Ibid. p. 622, pl. i. fig. 37.
Nodosaria (*Dentalina*) *reitzi*, Hantken, 1868, Magyar. Föld. Társ., vol. iv. p. 88, pl. i. fig. 13.
Dentalina jurensis, Terquem (pars), 1870, Foram. du Syst. Oolith., 3ième mém., p. 260, pl. xxvii. figs. 6–16.
„ *communis*, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 158, pl. ix. fig. 46.
Nodosaria (*D.*) *peracuta*, Reuss, 1874, Das Elbthalgebirge in Sachs., pt. 2, p. 86, pl. ii. fig. 21.
Dentalina communis, Brady (pars), 1876, Monogr. Carb. and Perm. For., p. 127, pl. x. fig. 17.
Frondicularia cernua, Berthelin, 1879, Revue et Mag. de Zool. [separate copy, p. 9, pl. i. figs. 7, 8].

The drawing in the " Testaceographia," above referred to, represents a curved, tapering shell, with ten oval or inflated segments, separated by straight sutures. It was quoted

in the "Tableau Méthodique" as an illustration of *Nodosaria* (*Dentalina*) *communis;* but subsequently, when that species was described by d'Orbigny in his memoir on the Cretaceous Foraminifera of the vicinity of Paris, the name was applied to a somewhat different modification of the same type, having obliquely-set chambers. That both forms belong to the same specific series admits of no doubt; but in the classification of the varieties of smooth *Nodosariæ* into subordinate groups, the direction of the septa, whether straight or oblique, affords distinctive characters of some service; and under these circumstances the term *Nodosaria communis* may properly be employed in a restricted sense for the variety with oblique sutures.

It has been the custom to ignore the names under which Soldani described his specimens, on the ground that his nomenclature is seldom in accordance with the Linnean method; and further, because he not unfrequently comprehends under one general name a miscellaneous assortment of organisms having little or no relationship with each other from a modern point of view. In the present instance no such objection arises. The term *Orthoceras farcimen* is coupled with a single specimen, and is accompanied by a description which, taken with the figure, is sufficient for the identification of the form. Reuss, in his memoir on the Foraminifera of the Crag of Antwerp, adopts Soldani's name, illustrating the characters of the species by a somewhat shorter specimen than that portrayed in the original figure. There is some degree of doubt as to the particular variety for which Lamarck's term *Nodosaria dentalina* was intended, and in the absence of any other early appellation for the present form, it appears most convenient to follow Reuss in adopting the Soldanian name.

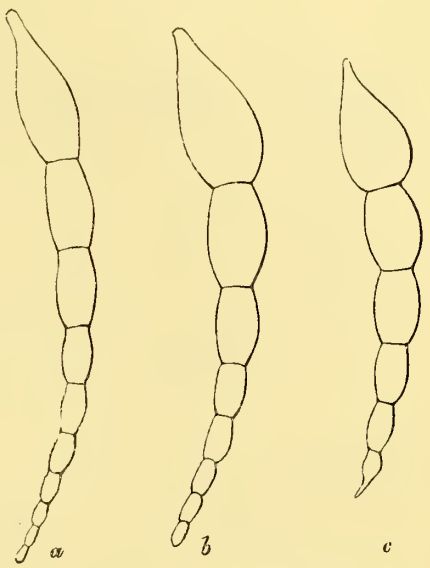

Fig. 13.—*Nodosaria farcimen*, Soldani, sp.
a. Copied from Soldani.
b. Copied from Reuss (Crag of Antwerp).
c. Cretaceous specimen.

The woodcuts (fig. 13, *a.b.c.*) sufficiently illustrate the morphological characters of the organism in question. The drawings (Pl. LXII. figs. 17, 18) represent specimens which cannot be separated, even varietally, from these, but they are by no means typical, the segments being shorter and the general form of the shell more rapidly tapering.

Nodosaria farcimen is a true cosmopolite, being found in every sea and at almost every depth from the littoral zone down to 2000 or 3000 fathoms.

In the fossil condition it makes its appearance at least as far back as the Magnesian Limestones of the Permian system, and it occurs in microzoic rocks of almost every subsequent age.

Nodosaria (D.) filiformis, d'Orbigny (Pl. LXIII. figs. 3–5).

"Orthoceratia filiformia aut capillaria," Soldani, 1798, Testaceographia, vol. ii. p. 35, pl. x. fig. *e*.
Nodosaria filiformis, d'Orbigny, 1826, Ann. Sci. Nat., vol vii. p. 253, No. 14.
Dentalina acutissima, } d'Orbigny, 1839, Foram. Amér. Mérid., p. 23, pl. iii. figs. 15, 16.
,, *acuta*, }
,, *gracilis*, Id. 1840, Mém. Soc. géol. France, vol. iv. p. 14, pl. i. fig. 5.
,, *elegans*, Id. 1846, For. Foss. Vien., p. 45, pl. i. figs. 52–56.
,, *reussi*, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 85, pl. iii figs. 6, 7.
,, *prælonga*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 163, pl. xii. fig. 21.
,, *vetustissima*, Terquem, 1858, Foram. du Lias, 1ière mém. p. 600, pl. ii. fig. 8.
,, *baccata*, Id. Ibid. p. 601, pl. ii. fig. 9.
,, *pseudomonile*, Id. Ibid. p. 606, pl. ii. fig. 18.
Nodosaria elegans, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 233, pl. vi. fig. 68.
Dentalina filiformis, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 156, pl. ix. fig. 48.

The Soldanian drawing, which serves as the basis of the present species, represents a long, slender, slightly bent, Nodosarian shell, with numerous short oval segments. The segments are more distinctly oval and more regular than those of the specimens figured in Pl. LXIII., which are not good illustrations of the typical form.

Nodosaria filiformis has been collected both in the North and South Atlantic and in the North and South Pacific, at depths ranging from 50 to 450 fathoms, but typical examples are by no means common.

In the fossil state it is met with as far back as the Lias, and is found associated with its congeners in many subsequent microzoic formations.

Nodosaria (D.) pauperata, d'Orbigny (woodcuts, fig. 14, *a.b.c.*).

Dentalina pauperata, d'Orbigny, 1846, For. Foss. Vien., p. 46, pl. i. figs. 57, 58.
,, *inermis*, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 139, pl. xii. figs. 3–7.
,, *terquemi*, d'Orbigny, 1850, Prodrome de Paléont., vol. i. p. 242, No. 257.
,, *annulata*, Reuss, 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 26, pl. ii. fig. 13.
,, *pauperata*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 324, pl. xiii. fig. 7.
,, *terquemi*, Terquem, 1858, Foram. du Lias, 1ière mém. p. 596, pl. ii. fig. 1.
,, *communis* (pars), Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, p. 58, pl. i. fig. 15.
,, *pauperata*, Brady, 1867, Proc. Somerset. Arch. and Nat. Hist. Soc., vol. xiii. p. 108, pl. i. fig. 14.

The test of *Nodosaria pauperata* is described by d'Orbigny as short and stout, slightly arched, smooth externally, and formed of chambers of nearly equal size; the earlier segments not projecting externally, the later ones convex and separated by deep

sutures; the primordial segment relatively large and terminating in a point, the final one acuminate and pierced with a rounded orifice.

Amongst the curved *Nodosariæ* with straight sutures, it is convenient to distinguish by name the group of intermediate forms characterised by the foregoing description; those, namely, which are subcylindrical at the commencement and subsequently moniliform, most of the chambers having no external depressions on the septal lines, a few of the later ones becoming inflated or subglobular. Such shells are as a rule few-chambered and stoutly built; they are generally of nearly even width, tapering a little towards the initial end.

Speaking in general terms, the distribution of *Nodosaria pauperata*, whether geographical or geological, corresponds with that of the closely allied *Nodosaria farcimen* and *Nodosaria communis*.

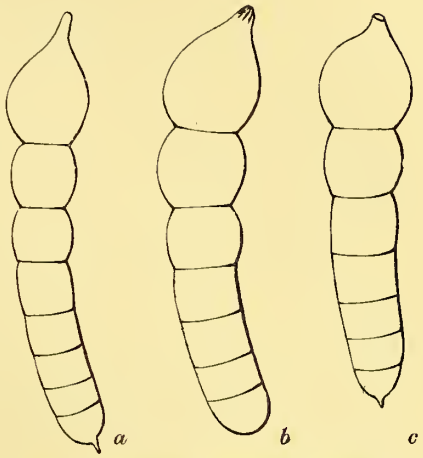

Fig. 14.—*Nodosaria pauperata*, d'Orbigny.
a. Miocene specimen, copied from d'Orbigny.
b. Recent specimen.
c. Liassic specimen.

Nodosaria (*D.*) *consobrina*, d'Orbigny (Pl. LXII. figs. 23, 24).

Dentalina consobrina, d'Orbigny, 1846, For. Foss. Vien., p. 46, pl. ii. figs. 1–3.
Nodosaria culmen, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 158, pl. xiii. fig. 15.
Dentalina haidingerii, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 85, pl. iii. fig. 12.

„	*consobrina*,	Id.	Ibid.	p. 86, pl. iii. fig. 15.
„	*reussi*,	Id.	Ibid.	p. 85, pl. iii. fig. 17.
„	*abbreviata*,	Id.	Ibid.	p. 86, pl. iii. fig. 18.

Nodosaria consobrina, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 473, No. 18;—Schlicht, 1870, Foram. Pietzpuhl, pl. ix. figs. 1, 2, 8, 22; pl. x. figs. 25–27.

This is a smooth, attenuated, and generally Dentaline variety, of which the early segments are short, and those subsequently formed of elongate-oval contour. Reuss allows to *Nodosaria consobrina* considerable range of variation as to minor characters, and gives references to an instructive series of figures in von Schlicht's memoir. The little two-chambered shell figured by Parker and Jones under this name (Phil. Trans., vol. clv. pl. xvi. fig. 3) appears to me to belong to *Nodosaria calomorpha*, Reuss, a very distinct form.

The distribution of *Nodosaria consobrina* cannot be distinguished from that of the more slender variety, which follows next in order.

Nodosaria consobrina, var. *emaciata*, Reuss (Pl. LXII. figs. 25, 26).

Dentalina emaciata, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 63, pl. iii. fig. 9.
„ *prælonga*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 163, pl. xii. fig. 21.
Nodosaria (*D.*) *consobrina*, var. *emaciata*, Reuss, 1865, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 132, pl. ii. figs. 12, 13.

Reuss's later drawings of this variety accord precisely with the recent specimens figured in Pl. LXII. The shell differs from that of the type chiefly in its greater length, the larger number of its segments, and their relatively shorter contour.

Nodosaria consobrina, whether of the typical form or the "emaciate" variety, is found living in the North Atlantic at depths ranging from 290 to 725 fathoms; in the South Atlantic at 350 fathoms; off the Cape of Good Hope, 150 fathoms; and in the South Pacific, from 129 to 1375 fathoms. There is no record of its occurrence in the North Pacific.

Fossil specimens have been procured from the following amongst other geological formations:—the Chalk of Ireland (Wright); the London Clay (Jones and Parker); the Septaria-clays of Germany (Reuss, Bornemann, &c.); the *Clavulina-szabói* beds of Hungary (Hantken); the Miocene of various parts of Austria (d'Orbigny, Neugeboren, Karrer, &c.); the later Tertiaries of Italy (Costa); and the Post-tertiary beds of Norway (Crosskey and Robertson), of Scotland (Robertson), and of the Island of Ischia (Vanden Broeck).

Nodosaria (*D.*) *plebeia*, Reuss (Pl. LXIII. fig. 2).

Dentalina plebeia, Reuss, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 267, pl. viii. fig. 9.
„ *megalopolitana*, Id. Ibid. p. 267, pl. viii. fig. 10.
„ *tenuicollis*, (?) Id. Ibid. p. 267, pl. viii. fig. 11.
Dentalina æqualis, Karrer, 1864, Novara-Exped. geol. Theil, vol. i., Paläont., p. 74, pl. xvi. fig. 1.
Nodosaria vermiculum, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 133, pl. ii. figs. 14, 15.
„ *approximata*, Id. Ibid. p. 134, pl. ii. fig. 22.
Dentalina plebeia, Brady, 1867, Proc. Somerset. Arch. and Nat. Hist. Soc., vol. xiii. p. 108, pl. i. fig. 15.
Nodosaria vermiculum, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 474, No. 22;—Schlicht, 1870, Foram. Pietzpuhl, pl. viii. figs. 18; pl. x. figs. 5–9, 11.

This species was founded by Reuss on specimens obtained from the Chalk of Mecklenburg. The test is cylindrical and somewhat curved, tapering and more or less pointed at the extremities; the segments are numerous and the septal lines transverse and straight; the outline of the shell is even and exhibits no sutural constrictions, the septa being marked externally by lines only.

Dentalina megalopolitana has the same morphological characters as *Dentalina plebeia*, but is more stoutly built; and *Dentalina tenuicollis* is likewise similar, but has an

abnormally large primordial chamber; whilst *Nodosaria approximata* differs only in its greater length and larger number of segments. Characters like these cannot be accepted as valid zoological distinctions, on any principle short of naming each individual specimen.

In the recent condition *Nodosaria plebeia* is rare, but it has been found with allied forms in the North Atlantic, at a depth of 435 fathoms.

As a fossil it occurs in the Middle Lias and in the Chalk, as well as in certain deposits of Tertiary age.

Nodosaria (*D.*) *soluta*, Reuss (Pl. LXII. figs. 13–16;—var. Pl. LXIV. fig. 28).

Dentalina oligostegia, Reuss, 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 25, pl. ii. fig. 10.
„ *lilli*, Id. Ibid. p. 25, pl. ii. fig. 11.
„ *soluta*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 60, pl. iii. fig. 4, *a.b.*
„ *globifera*, Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 223, pl. i. fig. 3.
Nodosaria soluta, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 322, pl. xii. fig. 12.
Dentalina globuligera, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 81, pl. ii. fig. 10.
Nodosaria ovularis, Costa, 1857, Mem. Accad. Sci. Napoli, vol. ii. p. 141, pl. i. figs. 8, 9.
Dentalina distincta, Reuss, 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xl. p. 184, pl. ii. fig. 5.
„ *catenula*, Id. Ibid. p. 185, pl. iii. fig. 6.
„ *discrepans*, Id. Ibid. p. 184, pl. iii. fig. 7.
Dentalina soluta, Stache, 1864, Novara-Exped., geol. Theil, vol. i., Paläont., p. 203, pl. xxii. fig. 29.
Nodosaria (*D.*) *grandis*, Reuss, 1865, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 131, pl. i. figs. 26–28.
„ „ *soluta*, Id. Ibid. p. 131, pl. ii. figs. 4–8.
„ „ *guttifera*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 343, pl. xiii. fig. 11.
Dentalina soluta, Hantken, 1875, Mitth. Jahrb. d. k. ung. geol. Anstalt., vol. iv. p. 29, pl. ii. figs. 2, 14.

Nodosaria soluta is on the whole the most typical representative of a group of *Nodosariæ* characterised by large globular segments of nearly equal size. The segments are comparatively few in number, usually from three to five, but occasionally as many as eight; the primordial chamber is often relatively large, and nearly always mucronate. The shell is sometimes a good deal bent, but more often nearly straight; it varies in magnitude from $\frac{1}{25}$th to $\frac{1}{5}$th inch (1 to 5 mm.) and in rare cases attains a length of $\frac{1}{3}$rd inch (8·4 mm.), or even more. The presence or absence of the terminal mucro and other quite unimportant details have been made the ground of distinction in most of the forms enumerated in the synonymy. The figures given in Pl. LXII. sufficiently illustrate the general characters of the species; the specimen represented in Pl. LXIV. fig. 28, exhibits very faint superficial striæ on the basal aspect of the segments.

Nodosaria soluta is not uncommon in the North Atlantic, at depths ranging from 300

to 900 fathoms, and has been found as low as 1360 fathoms. In the South Atlantic its range, so far as has been ascertained, is from 350 to 675 fathoms; whilst in the South Pacific it affects shallower water, namely, from 125 to 410 fathoms, though in one locality it occurs at 1350 fathoms.

The geological distribution of the species extends from the Cretaceous period forward to the present time.

Nodosaria (?) *abyssorum*, H. B. Brady (Pl. LXIII. figs. 8, 9).

Nodosaria abyssorum, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 63.

Test straight or only slightly curved, moniliform, often irregularly built; walls thick and opaque; segments five to nine in number, subglobose, somewhat uneven both as to shape and size; primordial chamber, which is usually the largest, armed with a number of short, stout, terminal spines; aperture situated in a short, wide neck, with large phialine lip. Length, $\frac{1}{8}$th inch (3·15 mm.), or more.

Little need be added to the foregoing description of this species. It is not by any means certain that it really belongs to the genus *Nodosaria*, that it is not rather a deep-sea variety of *Sagrina*, allied to the monomorphous forms of *Sagrina virgula* (Pl. LXXVI. figs. 8–10); but in the absence of intermediate specimens or other collateral evidence the Nodosarian contour of the shell must be allowed to dictate its generic position.

Nodosaria (?) *abyssorum* has only been found in one locality:—Station 296, South Pacific, south-west of Juan Fernandez, depth 1825 fathoms. The specimens are tolerably numerous, and some of them are longer and possess a greater number of segments than those from which the figures are taken.

Nodosaria (*D.*) *communis*, d'Orbigny (Pl. LXII. figs. 19–22).

Nodosaria (*Dentalina*) *communis* (?), d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 254, No. 35.
Dentalina communis, Id. 1840, Mém. Soc. géol. France, vol. iv. p. 13, pl. i. fig. 4.
Nodosaria communis, Reuss, 1845, Verstein. Böhm. Kreid., pt. i., p. 28, pl. xii. fig. 21.
„ *legumen* Id. Ibid. p. 28, pl. xiii. figs. 23, 24.
Dentalina inornata, d'Orbigny, 1846, For. Foss. Vien., p. 44, pl. i. figs. 50–51.
„ *badenensis*, Id. Ibid. p. 44, figs. 48, 49.
„ *ferstliana*, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 140, pl. xii. figs. 10–13.
„ *haueri*, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 81, pl. ii. fig. 12.
„ *orbignyana*, Id. Ibid. pl. iii. figs. 1–3.
„ *subarcuata*, Williamson, 1858, Rec. For. Gt. Br., p. 18, pl. ii. figs. 40, 41.
„ *torta*, Terquem, 1858, Foram. du Lias, 1ière mém., p. 599, pl. ii. fig. 6.

Dentalina vetusta, Terquem, 1858, Foram. du Lias, 1ire mém., p. 598, pl. ii. fig. 4.
legumen, Reuss, 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xl. p. 187, pl. iii. fig. 5.
„ *intermedia*, Id. Ibid. p. 186, pl. ii. fig. 8.
„ *communis*, Id. Ibid. p. 186.
„ „ Parker and Jones, 1862, Introd. Foram., Appendix, p. 310.
, *deflexa*, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 43, pl. ii. fig. 19.
, *inornata*, Id. 1863, Ibid. vol. xlviii. p. 45, pl. ii. fig. 18.
„ *boettcheri*, Id. Ibid. p. 44, pl. ii. fig. 17.
Nodosaria neugeboreni, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 232, pl. vi. fig. 67.
„ *gracilescens*, Id. Ibid. p. 234, pl. vi. fig. 70.
Dentalina intorta, Terquem, 1870, Foram. du Syst. Oolith., 3ième mém., p. 262, pl. xxvii. figs. 26–34.
„ *budensis*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 34, pl. iii. fig. 12.

As already explained in the notes upon *Nodosaria farcimen*, the description and figure furnished by d'Orbigny, in his memoir on Foraminifera of the White Chalk of the Paris Basin, constitute the best basis for the present species (p. 499).

In the classification of the smooth-shelled Nodosarians into varietal or quasi-specific groups, by characters derived from the shape and mode of combination of the chambers, *Nodosaria communis* affords the best type of the slender arcuate forms with oblique segments. Besides the Cretaceous examples above referred to, good typical specimens of this sort are figured by d'Orbigny in the "Vienna Basin" monograph, as *Dentalina inornata* and *Dentalina badenensis*, and by Williamson as *Dentalina subarcuata*. The foregoing list of synonyms appears somewhat lengthy, but it might have been greatly increased without infringing the morphological limits of a moderately restricted varietal group.

Nodosaria communis has the same world-wide distribution as the closely allied *Nodosaria farcimen*, and a similar geological range.

Nodosaria (*D.*) *roemeri*, Neugeboren (Pl. LXIII. fig. 1).

Dentalina roemeri, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 82, pl. ii. figs. 13–17.
Dentalina nana, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 39, pl. ii. figs. 10, 18.
Nodosaria roemeri, Id., 1870, Ibid. vol. lxii. p. 475;—Schlicht, 1870, Foram. Pietzpuhl, pl. x. figs. 21, 22, 24.

This form occupies very much the same position amongst the curved *Nodosariæ* with obliquely-set chambers, that *Nodosaria pauperata* holds amongst those with straight sutures. The test is short and stoutly built, cylindrical and slightly bent, and the primordial end is rounded. The earlier segments are close-fitting, and the septa are marked by oblique lines without external depressions; the later segments are more or

less inflated and the sutures excavated. It is allied on one hand to *Nodosaria communis*, and on the other to *Nodosaria mucronata*; from the former it differs in its stouter proportions and flush sutures, and from the latter in its less rapidly tapering contour and rounded initial end.

The variety is not common in the living condition, and it is difficult to lay down its area of distribution, distinct from that of *Nodosaria communis*. It has been observed chiefly in the North Atlantic, at depths of less than 400 fathoms.

As a fossil it has been obtained from the Gault of Germany (*Dentalina nana*, Reuss); from the Septaria-clays of Germany (Reuss, Schlicht); and from the Miocene of Transylvania (Neugeboren).

Nodosaria (*D.*) *mucronata*, Neugeboren (Pl. LXII. figs. 27–29; monstrous specimens, figs. 30, 31).

"Orthoceras *intortum*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 98, pl. cv. fig. *V*.
Nodosaria (*Dentalina*) *obliqua*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 254, No. 36, Modèle, No. 5.
Dentalina mucronata, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 83. pl. iii. figs. 8–11.
„ *plebeia*, Terquem, 1870, Foram. du Syst. Oolith., 3ième mém., p. 267, pl. xxix. figs. 3–11.
„ *cornuformis*, „ *bicornis*, } Id. Ibid. p. 268, pl. xxix. figs. 13–17.
Nodosaria mucronata, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 475, No. 30;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxxviii. fig. 6, &c.
Dentalina communis, subvar. *obliqua*, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 264, pl. ix. fig. 47.
„ *obliqua*, Wright, 1880, Proc. Belfast Nat. Field Club, 1879–80, App., p. 207.

The *Nodosaria* (*Dentalina*) *obliqua* of the "Tableau Méthodique" is exemplified by a tapering shell, somewhat broad near the oral end, and with oblique sutures which are marked externally by slightly excavated lines. It is a tolerably well defined sub-varietal form, but the name applied to it had previously been assigned by Linné to a costate variety of the same genus.

Dentalina mucronata, as figured by Neugeboren, presents almost identical characters, but the primordial end of the test is more definitely pointed. In deep-water specimens the shell-wall is often very thin and the septation defective, and monstrous developments, such as are shown in figs. 30, 31, are not unfrequent. As stated by Reuss in his notes upon von Schlicht's figures (*loc. cit.*), *Nodosaria mucronata* is one of the transition forms connecting the genus with *Marginulina*, and is closely allied to *Marginulina apiculata* of the Chalk (Haidinger's Naturw. Abhandl., vol. iv. p. 28, pl. ii. fig. 18).

Nodosaria mucronata has been collected in comparatively shallow water on our own

shores and also in the Adriatic. The Challenger specimens are almost exclusively from deep bottoms, namely:—from the North Atlantic, 1750 fathoms; South Atlantic, 2200 fathoms and 2350 fathoms; Southern Ocean, 1570 fathoms; South Pacific, seven Stations, 620 to 2600 fathoms; and North Pacific, 345 fathoms.

Fossil examples are recorded from the Septaria-clays of Germany (Reuss), the Miocene of Transylvania (Neugeboren), and of Malta (Brady), as well as from some later Tertiary formations.

Nodosaria subtertenuata, Schwager (Pl. LXII. figs. 7, 8).

Nodosaria subtertenuata, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 235, pl. vi. fig. 74.

This is a sub-varietal modification of the straight Nodosarian type, with distinct elliptical segments, the earlier segments being relatively small, and the surface of the shell rough or slightly aculeate.

The recent specimens are from the Ki Islands, 129 fathoms.

Those originally figured by Schwager were fossils from the Upper Pliocene formation of the Nicobar Islands.

Nodosaria (*D.*) *retrorsa*, Reuss (Pl. LXIII. fig. 7).

Dentalina retrorsa, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 46, pl. iii. fig. 27.

A slender Dentaline variety, with elongate-oval or fusiform segments, the basal ends of which are armed with a small number of delicate spines.

Habitat, off the Ki Islands, 580 fathoms.

The specimens described by Reuss were fossils from the Septaria-clay of Offenbach in Germany.

Nodosaria hispida, d'Orbigny (Pl. LXIII. figs. 12–16).

"Orthoceratia quasi *hispida*," Soldani, 1798, Testaceographia, vol. ii. p. 15, pl. ii. fig. *P.*
"Orthoceratia *hispida*," Id. Ibid. p. 36, pl. xi. figs. *n–z. A. B.*
Nodosaria hirsuta, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 252, No. 7 (*fide* d'Orbigny).
„ *hispida*, Id. 1846, For. Foss. Vien., p. 35, pl. i. figs. 24, 25.
„ *aculeata*, Id. Ibid. p. 35, pl. i. figs. 26, 27.
Dentalina floscula, Id. Ibid. p. 50, pl. ii. figs. 16, 17.
Nodosaria conspurcata, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 59, pl. iii. fig. 3.
„ *asperula*, Neugeboren, 1852, Verhandl. u. Mitth. siebenb. Vereins f. Naturw., Jahrg. iii. p. 54, pl. i. figs. 40, 41.

Nodosaria hispida, Neugeboren, 1852, Verhandl. u. Mitth. siebenb. Vereins. f. Naturw., Jahrg. iii. p. 54.
„ *armata*, Id. Ibid. p. 56, pl. i. fig. 44.
„ *spinosa*, Id. Ibid. p. 56, pl. i. fig. 45.
„ *conspurcata*, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 43, pl. ii. figs. 10–12.
„ *hispida*, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 154 pl. ix. fig. 45.
„ „ Silvestri, 1872, Nodos. Foss. e Viv. d'Ital., p. 80, pl. ix. figs. 207–228.

Silvestri devotes an entire plate of his beautiful memoir on Italian *Nodosariæ* to the exposition of the morphological range of this species. A specimen not unlike the one portrayed in Pl. LXIII. fig. 16, is selected as the type, and the series of drawings embraces every intermediate stage between that form and the attenuated varieties with small chambers and long stoloniferous tubes, represented in figs. 14 and 15. This view of the variability of the species is fully borne out by the Challenger collections.

The two little shells represented by figs. 10 and 11 differ in certain particulars from the other aculeate specimens, and it is difficult to say whether they are arrested individuals of the present species, or belong to one of the allied forms like *Nodosaria setosa*, Schwager (Novara Exped., geol. Theil, vol. ii. p. 218, pl. v. fig. 4), to which in some respects they bear greater resemblance.

The distribution-list of *Nodosaria hispida* includes three Stations in the North Atlantic, depth 390 to 450 fathoms; one in the South Atlantic, south-east of Pernambuco, 350 fathoms; five in the South Pacific, 150 to 355 fathoms; and one in the North Pacific, Philippine Islands, 95 fathoms; it also occurs in the Mediterranean and the Adriatic.

As a fossil it has been found in the Middle and Upper Lias of the west of England (Brady, Walford); in the Chalk of the north-east of Ireland (Wright); in the London Clay (Jones and Parker); in the Septaria-clay of various parts of Germany (Reuss); in the Miocene of Austria (d'Orbigny, Neugeboren, &c.), and of Malta (Brady); in the *Clavulina-szabói* beds of Hungary (Hantken); in the Subapennine deposits of Italy (Soldani, Silvestri, &c.), and in the later Tertiary clay of the neighbourhood of Malaga, (Jones and Parker).

Nodosaria hispida, var. *sublineata*, nov. (Pl. LXIII. figs. 19–22).

At one or two localities, many if not the majority of the specimens of *Nodosaria hispida* present a modified form of superficial ornament. On certain parts of the shell, particularly the middle and upper portions of the chambers, delicate raised lines take the place of the aculei, as shown in figs. 19–21. The origin of this peculiarity is explained by the enlarged drawing, fig. 22, which represents a single chamber in an intermediate condition; from which it appears that the production of the striæ is due to the fusion

of rows of exogenous beads or shortened spines. The difference between the ornament in this particular stage and that of *Nodosaria verruculosa* is exceedingly slight.

Nodosaria hispida, var. *sublineata*, has only been noticed at Station 33, off Bermuda, 435 fathoms, and at Station 122, south-west of Pernambuco, 350 fathoms.

Nodosaria verruculosa, Neugeboren (Pl. LXIII. figs. 17, 18).

Nodosaria verruculosa, Neugeboren, 1852, Verhandl. u. Mitth. siebenb. Vereins. f. Naturw., Jahrg. iii. p. 55, pl. i. fig. 43.

The rare living examples of this form are typified by straight shell with five subglobular segments, the exterior beset with little tubercles or warts. The specimen figured by Neugeboren, under the name *Nodosaria verruculosa*, as far as can be gathered from the description and the somewhat rough illustration, answers to these characters in all essential points.

The species has only been met with at one Challenger Station, off the Ki Islands, 129 fathoms.

The fossil specimens originally described were from the Miocene of Ober-Lapugy, in Transylvania.

Nodosaria comata, Batsch, sp. (Pl. LXIV. figs. 1–5).

Nautilus (*Orthoceras*) *comatus*, Batsch, 1791, Conchyl. des Seesandes, p. 2, pl. i. figs. 2, *a.b.c.d.*
Nodosaria (*Glandulina*) *glans*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 252, No. 2—Modèle, No. 51.
Nodosaria comata, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xv. p. 226, No. II.
Glandulina glans, Id. 1865, Ibid. vol. xvi. p. 27, pl. i. fig. 30.

Under the name *Nautilus* (*Orthoceras*) *comatus*, Batsch has figured two straight, tapering, Nodosarian shells, with a surface-ornament of thin longitudinal costæ. One of them is of short Glanduline form, resembling figs. 1, 2, and 3 of Pl. LXIV.; the other is of more slender build, something like fig. 5, but even longer proportionately; in both the ornament ceases near the middle of the final segment, leaving the surface smooth at the oral end. With a series of specimens before us, such as that from which the illustrations have been selected, it appears probable enough that the author was justified in assigning his two shells to the same species, notwithstanding their dissimilarity of contour.

That Batsch's shorter drawing, and some of the younger examples now figured, are identical with *Glandulina glans* of the "Tableau Méthodique" becomes evident on comparing them with d'Orbigny's model of the latter species; and it is worthy of

remark that in some localities a majority of the specimens never pass beyond the *Glandulina*-like stage.

Nodosaria comata has been obtained somewhat plentifully off Bermuda, 435 fathoms; and more sparingly off Culebra Island, West Indies, 390 fathoms; off Sombrero Island, West Indies, 450 fathoms; and in harbour-mud from Port Louis, Mauritius. It has been found also in the Adriatic.

Jones and Parker record its occurrence in the Subapennine Tertiaries of Italy.

Nodosaria scalaris, Batsch, sp. (Pl. LXIII. figs. 28–31; var. Pl. LXIV. figs. 16–19).

"Orthocerata striata microscopica," Soldani, 1780, Saggio Oritt., p. 107, pl. v. figs. *Z, A, B, C, D;* pl. viii. fig. *CC.*
"Orthoceratia *Flosculi*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 91, pl. xcv. figs. *B–M.*
"Polymorpha *Pineiformia*," Id. Ibid. p. 118, pl. cxxvii. fig. *C.* (monstrous specimen).
Nautilus (*Orthoceras*) *scalaris*, Batsch, 1791, Conchyl. des Seesandes, No. 4. pl. ii. fig. 4, *a.b.*
Nodosaria longicauda, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 254, No. 28.
„ *sulcata*, Id. Ibid. p. 253, No. 21 (monstrous).
„ *candei*, Id. 1839, Foram. Cuba, p. 44, pl. i. figs. 6, 7.
„ *striaticollis*, Id. 1839, Foram. Canaries, p. 124, pl. i. figs. 2–4.
„ *tenuicostata*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 156, pl. xii. fig. 5; and varieties, pl. xvi. figs. 8–13.
„ *reussi*, Id. Ibid. p. 155, pl. xvi. fig. 5.
„ *annulata*, Id. 1857, Mem. Accad. Sci. Nap., vol. ii. p. 139, pl. i. fig. 16.
„ *radicula*, Williamson, 1858, Rec. For. Gt. Br., p. 15, pl. ii. figs. 36–38.
„ *scalaris*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 340, pl. xvi. fig. 2, *a.b.c.*
„ *subradicula*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 222, pl. v. fig. 50.
„ *longicauda*, Silvestri, 1872, Nodos. Foss. e Viv. d'Ital., p. 58, pl. v. figs. 101–127.

Judged by typical specimens, this is a well differentiated species. The test is straight; the segments comparatively few, generally from three to six in the adult shell and never more than eight, inflated or subglobular, and increasing rapidly, though not always regularly, in size. The final chamber is drawn out into an apertural tube of some length with a terminal phialine lip, and the opposite extremity of the test is commonly mucronate. The superficial costæ vary both as to number and thickness, and are frequently more numerous and less strongly marked than shown by the figures. The range of variation in this and other particulars is very fully illustrated in the beautiful series of drawings given by Silvestri, under the name *Nodosaria longicauda* (*loc. cit.*). It is needful to remember that the present form is not the *Nodosaria scalaris* of d'Orbigny's "Tableau Méthodique."

At one or two localities the species exhibits a tendency to assume the peculiar habit of growth represented in Pl. LXIV. figs. 16–19. An apparently complete shell of three or

four segments, with the normal tubular neck, is first constructed (fig. 19), and subsequently another segment is added. The early segments are less inflated than usual in typical specimens, and the supplementary chamber, which is nearly spherical, is separated from the rest by the narrow stoloniferous tube. This is a local variety, and may be distinguished as *Nodosaria scalaris*, var. *separans*. The figured specimens are all from one sounding, off the west coast of New Zealand, 275 fathoms where it is tolerably abundant. Good examples were dredged by the late Edward Waller on the coast of Kerry.

Nodosaria scalaris is common on the shores of Norway, Denmark, Great Britain, Belgium, and France; and, though affecting shallow water, has been taken in the North Atlantic at various depths down to 1630 fathoms. It occurs in the Mediterranean and the Adriatic, off the Cape of Good Hope, and off the coast of Australia; at seven Stations in the South Pacific, 2 fathoms to 580 fathoms; off the Philippine Islands, 95 fathoms, and off the south coast of Japan, 345 fathoms.

The species is abundant in the Subapennine deposits of many parts of Italy (Soldani, Silvestri); it has been found in the Tertiary clay of the vicinity of Malaga (Jones and Parker), in the Crag of the east of England (Jones, Parker, and Brady), and in the Post-tertiary beds of the north-west of Ireland (Wright).

Nodosaria proxima, Silvestri (Pl. LXIV. fig. 15).

Nodosaria proxima, Silvestri, 1872, Nodos. Foss. e Viv. d'Ital., p. 63, pl. vi. figs. 138–147.

Silvestri, whose judgment is entitled to great respect, treats this little form as a distinct and recognisable species, and gives an excellent set of figures in support of this view. In some of the Challenger dredgings, notably in the rich coral sand from Torres Strait (Station 185), two-chambered costate *Nodosariæ*, having generally a larger number of ribs than the figured specimen (Pl. LXIV. fig. 15), and corresponding accurately with Silvestri's drawings, are very common, and no passage-forms connecting them with other species have been observed. At the same time it is open to question whether morphologically such shells are anything more than arrested specimens of *Nodosaria scalaris*, though perhaps sufficiently restricted and distinct in point of distribution to be treated as a local variety.

Nodosaria proxima occurs off the Azores, 450 fathoms; off Tristan d'Acunha, 100 to 150 fathoms; off Raine Island, Torres Strait, 155 fathoms; off the Philippines, 95 fathoms; and off the coral-reefs of Honolulu, 40 fathoms.

The specimens originally described were from the Subapennine clay of San Quirico near Sienna.

Nodosaria perversa, Schwager (Pl. LXIV. figs. 25–27).

Nodosaria perversa, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 212, pl. v. fig. 29.
„ *pupoides*, Silvestri, 1872, Nodos. Foss. e Viv. d'Ital., p. 65, pl. iv. figs. 148–158.

An imperfectly striate form, nearly related to *Nodosaria scalaris*. It is well figured both by Schwager and Silvestri, and the living specimens, especially that represented in fig. 25, closely resemble the drawings furnished by these authors.

In the living condition *Nodosaria perversa* has only been obtained off the Ki Islands, south-west of Papua, depth 129 fathoms.

The fossil specimens above referred to were from beds of later Tertiary age in the Nicobar Islands, Italy, and Sicily.

Nodosaria (*D.*) *subcanaliculata*, Neugeboren [var.] (Pl. LXIV. figs. 23, 24).

Dentalina subcanaliculata, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 87, pl. iv. figs. 5, 6.

Under the name *Dentalina subcanaliculata*, Neugeboren has figured two slender, curved, Nodosarian shells, which are characterised by their numerous segments, straight sutures, and a peculiar surface-ornament consisting of short, broken, longitudinal striæ. The specimen represented in Pl. LXIV. figs. 23, 24, exhibits the same kind of external marking; and as the test is manifestly abnormal in point of form, it may be treated provisionally, in the absence of other indications of its affinity, as an aberrant modification of the species referred to.

The recent shell was obtained from a sounding off Tahiti, 420 fathoms.

The original type-specimens were fossils from the Miocene of Transylvania.

Nodosaria raphanus, Linné, sp. (Pl. LXIV. figs. 6–10).

"Cornu Hammonis erectum striatum," Plancus, 1739, Conch. Min., p. 15, pl. i. fig. 6.
"Orthoceras minimum," &c., Gaultieri, 1742, Index Test., pl. xix. fig. *L*.
Nautilus raphanus, Linné, 1767, Syst. Nat., 12th ed., p. 1164, 283;—1788, Ibid., 13th (Gmelin's) Ed., p. 3372, No. 16.
"Orthoceratia seu tubuli," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 91, pl. xciv. figs. *T*, *V*.
Nautilus costatus, Montagu, 1803, Test. Brit., p. 199, pl. xiv. fig. 5.
„ „ var. Id. 1808, Ibid., Suppl., p. 83, pl. xix. fig. 2.
Orthocera raphanus, Lamarck, 1822, Anim. sans Vert., vol. vii. p. 593, No. 1;—Tabl. Encycl. et Méth., pl. cccclxv. fig. 2, *a.b.c.*
Nodosaria scalaris, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 253, No. 18.
„ *rapa*, Id. Ibid. p. 253, No. 27.
„ *obscura*, Reuss, 1845, Verstein. Böhm. Kreid., pt. 1, p. 26, pl. xiii. figs. 7–9.
„ *bolli*, Id. 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 265, pl. viii. fig. 6.
„ *propinqua*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 151, pl. xiii. fig. 2.

Nodosaria turgidula, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 152, pl. xiii. fig. 3.
„ *raphanus*, Parker and Jones, 1859, Ann. and Mag. Nat. Hist., ser. 3, vol. iii. p. 477.
„ *bactroides*, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 37, pl. ii. fig. 5.
„ *lamelloso-costata*, Id. Ibid. p. 38, pl. ii. fig. 6.
„ *prismatica*, Id. Ibid. p. 36, pl. ii. fig. 7.
„ *raphanus*, Silvestri, 1872, Nodos. Foss. e Viv. d'Ital., p. 43, pl. iv. figs. 67–81.
„ *obscura*, Reuss, 1874, Das Elbthalgebirge in Sachsen, pt. ii. p. 81, pl. xx. figs. 14.

Nodosaria raphanus may be accepted as the type of the stoutly built somewhat tapering Nodosarians, with comparatively few strongly developed costæ. The figures given by Plancus and Gaultieri allow considerable latitude as to minor particulars, that furnished by the latter author being relatively longer and more tapering than the rest. They represent jointly a group of forms with characters intermediate between those of *Nodosaria raphanistrum* and *Nodosaria scalaris*.

The species varies greatly in the size of the test and in the substance and prominence of the costæ. Under favourable conditions, at depths of 150 to 600 fathoms, specimens attain large dimensions, sometimes a length of $\frac{4}{10}$th inch (10 mm.) or even more. The costæ vary in number from about six to twelve; their outer margins are usually obtusely angular or blunt, but occasionally become thin and sharp as in the fine examples selected for the illustrations, Pl. LXIV. figs. 6–10. Specimens with prominent sharp-edged costæ, more or less resembling these, are figured by d'Orbigny as *Nodosaria lamellosa* (Ann. Sci. Nat., vol. vii. p. 253, pl. x. figs. 4–6), by Neugeboren as *Nodosaria compressiuscula* (Naturw. Verhandl. u. Mitth., Jahrg. iii. p. 59, pl. i. figs. 54–56), and by Silvestri as *Nodosaria acute-costata* (Nodos. Foss. e Viv. d'Ital, p. 48, pl. iv. figs. 82–89). Amongst the recent specimens are some precisely corresponding with the figures last quoted.

Nodosaria raphanus is found in the North and South Atlantic, the South Pacific, the Mediterranean, and the Adriatic, but I have no record of its presence in the North Pacific, and it is neither so common nor so generally distributed as the more slender and arcuate costate varieties. Its bathymetrical range appears to extend to about 1400 fathoms.

Geologically speaking, it is one of the oldest of the Nodosarian forms, occurring as far back as the Upper Trias; and it is of frequent occurrence in subsequent formations, both of Secondary and Tertiary age.

Nodosaria obliqua, Linné, sp. (Pl. LXIV. figs. 20–22).

"Orthoceras minimum," &c., Gaultieri, 1742, Index Test., pl. xix. fig. *N*.
Nautilus obliquus, Linné, 1767, Syst. Nat., 12th ed., p. 1163, 281;—1788, Ibid., 13th (Gmelin's) Ed., p. 3372, No. 14.
„ *jugosus*, Montagu, 1803, Test. Brit., p. 198, pl. xiv. fig. 4.
Orthocera obliqua, Lamarck, 1822, Anim. sans Vert., vol. vii. p. 594, No. 4.
Nodosaria sulcata, Nilsson, 1827, Petrif. Suec., p. 8, pl. ix. fig. 19.

Nodosaria elegans, Roemer, 1838, Neues Jahrb. für Min. &c., p. 382, pl. iii. fig. 1.
Dentalina bifurcata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 367, pl. xlvi. fig. 10.
„ *steenstrupi*, Id. 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 268, pl. viii. fig. 14, *a*.
„ *sulcata*, Id. Ibid. p. 269, pl. viii. fig. 14, *b*.
„ *baltica*, Id. Ibid. p. 269, pl. viii. fig. 15.
„ *muensteri*, Id. 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 225, pl. i. fig. 8.
„ *bifurcata*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 162, pl. xii. fig. 27.
Nodosaria mutabilis, Id. Ibid. p. 150, pl. xiii. fig. 1.
„ *siphunculoides*, Id. 1857, Mem. Accad. Sci. Nap, vol. ii. p. 135, pl. i. fig. 27.
Nodosaria (*Dentalina*) *obliqua*, Parker and Jones, 1859, Ann. and Mag. Nat. Hist., ser 3, vol. iii. p. 482.
Dentalina polyphragma, Reuss, 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xl. p. 189, pl. iii. fig. 1.

Gaultieri's figure, selected by Linné as the type of *Nautilus obliquus*, represents a somewhat bent and tapering Nodosarian shell, with slightly depressed sutures, and ornamented externally with numerous, moderately fine, longitudinal costæ—very similar, in fact, to the specimens portrayed in Pl. LXIV., but of somewhat stouter contour.

The above synonymy embraces only a few of the names which have been given to forms which lie well within the limits of the quasi-specific group typified by the original figure, and no attempt has been made to render the list complete.

Costate Nodosarians referrible to this species are found in every sea, and at almost every depth from the laminarian zone down to 1500 or 2000 fathoms.

In the fossil state they occur as far back as the Lower Lias, if not earlier, and thenceforward in marine beds of nearly every geological age.

Nodosaria vertebralis, Batsch, sp. (Pl. LXIII. fig. 35; Pl. LXIV. figs. 11–14).

Nautilus (*Orthoceras*) *vertebralis*, Batsch, 1791, Conchyl. des Seesandes, p. 3, No. 6, pl. ii. fig. 6, *a.b.*
Nodosaria fascia, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xv. p. 227, No. VI.

The shell of *Nodosaria vertebralis* is long, slender, slightly tapering, and generally more or less curved; the segments are very numerous and the septal lines straight; and the surface is marked by distinct, continuous, longitudinal striæ or riblets. The outline is even and the sutures are unconstricted; the septa are conspicuously thick and formed of transparent shell-substance, but not limbate externally.

Batsch's figures are drawn from a broken specimen, but as usual they give an accurate idea of its characteristic points. They have been assigned to *Nodosaria fascia*, Linn., sp., but Gaultieri's figure, on which that species is based, indicates a relatively broad stout shell, with raised or limbate sutures.

Nodosaria vertebralis occurs in the North Atlantic,—off Bermuda, off the Azores, and amongst the West Indian Islands, at depths of 300 to 450 fathoms; and at various Stations amongst the Islands of the South Pacific, at 120 to 300 fathoms.

Nodosaria catenulata, n. sp. (Pl. LXIII. figs. 32–34).

Test long and slender, straight or slightly arcuate, tapering; inferior extremity mucronate; segments numerous, elliptical, separated by deep sutures. Surface-ornament consisting of four equidistant longitudinal ribs, bridging the depressions between the segments. Length, $\frac{1}{14}$th inch (1·8 mm.).

Perhaps a variety of *Nodosaria vertebralis*. It has elliptical segments and the ribs are not continuous, but only bridge the sutural depressions without extending over the outer convex surfaces of the chambers.

The form has been taken off the Philippine Islands, 95 fathoms, and off Raine Island, Torres Strait, 155 fathoms.

Nodosaria costulata, Reuss (Pl. LXIII. figs. 23–27).

Nodosaria stipitata, var. *costulata*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 471;—Schlicht, 1870, Foram. Pietzpuhl, pl. vii. fig. 20.

This slender and elegantly formed shell has the general contour of *Nodosaria pyrula*, the segments being oval or subfusiform, and separated by narrow stoloniferous tubes; but the walls are thick and the basal aspect of each chamber is decorated externally with raised costæ. The costæ are short and do not extend beyond the middle of the segments. The only published figure corresponding to the recent specimens is one of a broken shell from the Septaria-clay of Pietzpuhl, given in von Schlicht's work (*loc. cit.*).

Fine examples of *Nodosaria costulata* have been obtained from three Stations in the North Atlantic:—off Sombrero Island, West Indies, 450 fathoms; off Culebra Island, West Indies, 390 fathoms; and off Bermuda, 435 fathoms; as well as at one point near the Philippine Islands, 95 fathoms.

Nodosaria (*D.*) *intercellularis*, H. B. Brady (Pl. LXV. figs. 1–4).

Nodosaria intercellularis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 63.

Test more or less arcuate, inferior extremity mucronate; composed of about six segments, the earlier of which are short and slightly inflated, the later ones elliptical or pyriform. Surface-ornament of the earlier segments consisting of longitudinal costæ; the later chambers marked by lines of closely set perforations which communicate with chamberlets formed in the furrows between the ribs. Aperture situated in a produced

terminal neck, with annular or spiral raised ornament and phialine or cleft lip. Length, $\frac{1}{15}$th inch (1·7 mm.).

In the general form of the test and the disposition of the chambers there is little to distinguish this species from some of its congeners, but the minute structure of the shell-wall of the later segments displays certain remarkable features.

The normal Nodosarian shell consists of a homogeneous and finely tubulated calcareous lamina; but the present species exhibits, in addition to this primary investment, a supplementary, external, cellulated layer. The structure is perhaps best explained by supposing it to have originated in a costate Nodosarian shell, in which the furrows between the ribs had been covered over, and the passages so formed subdivided by cross partitions. The actual condition of the shell-wall is readily understood from the transverse and longitudinal sections figured in the accompanying woodcuts. The transverse section (fig. *a*) shows little beyond the primary investment with its minute tubulation, and the exogenous costæ; for, owing to the extreme tenuity of the external covering, it has been almost entirely lost in the process of grinding. But in the longitudinal section (fig. *b*), which is much more highly magnified, the supplementary structures are better preserved; and not only are the outer film, and the partition-walls dividing the intercostal furrow into cells, shown *in sitû*, but the pores by which the cells communicate with the exterior are also clearly defined. Owing to its soft spongy texture, the external layer is easily broken away, without injuring the more solidly constructed investment underneath; and it was the occurrence of specimens in the abraded condition represented in Pl. LXV. fig. 4, that first directed attention to the anomalous character of the shell.

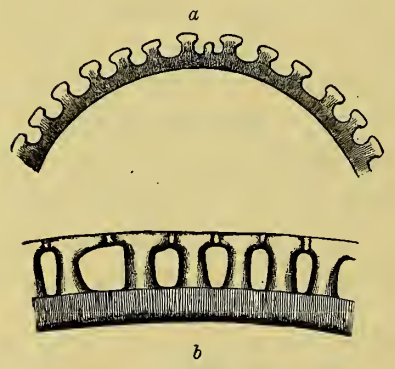

Fig. 15.—*Nodosaria intercellularis.*

a. Transverse section of the shell, magnified 200 diameters.

b. Longitudinal section, magnified 400 diameters.

There is an obvious similarity in structure between the test of *Nodosaria intercellularis* and that of *Lagena hertwigiana* described on a former page, the chief difference being the greater thickness and the well-marked tubulation of the primary wall of the former. Dr. Schwager has figured (Novara-Exped., geol. Theil, vol. ii., pl. v. fig. 26) what appears to be a single chamber of the present species, under the impression that it might belong to the genus *Ovulites*. The structural resemblance of these forms to some of the *Dactyloporidæ* is in many ways remarkable, the more so as recent researches tend to show that it is purely accidental.

Nodosaria intercellularis has only been found at one locality, namely,—Station 33 off Bermuda, depth 435 fathoms.

Lingulina, d'Orbigny.

"Orthoceratium," pars, Soldani [1791].
Lingulina, d'Orbigny [1826], Reuss, Bornemann, Costa, Neugeboren, Williamson, Parker and Jones, Karrer, Carpenter, Schwager, Stache, Pourtales, Gümbel, &c.
Nodosaria (*Mucronina*), d'Orbigny [1826].

The generic term *Lingulina* is reserved for the compressed modifications of the straight *Nodosariæ*. Such species may have either the elongate slender proportions of the typical Nodosarians or the shortened contour of the Glanduline members of the genus. The aperture is normally a narrow fissure corresponding in shape to the transverse section of the final segment, but frequently takes the form of a round or oval orifice, either somewhat produced as in *Nodosaria*, or situated at the middle of an elongate depression.

These characters are too variable to be of much zoological value, and the forms to which they apply represent rather the transition stages between *Nodosaria* proper and *Frondicularia*, than a definite generic group.

Except in the tropical and sub-tropical portions of the Atlantic, at depths of from 300 to 600 fathoms, recent *Lingulinæ* are nowhere abundant; nevertheless the genus is met with to a greater or less extent in both the North and South Pacific, the Mediterranean and the Adriatic. Its geological range extends from the Liassic period to the present time. In the Miocene age the costate varieties appear to have been widely diffused, but otherwise the type is of limited distribution.

Lingulina carinata, d'Orbigny (Pl. LXV. figs. 16, 17).

"Testæ *Ovales, oliviformes, pyriformes, fusiformes*," &c., Soldani, 1798, Testaceographia, vol. ii. p. 37, pl. xii. fig. *P.*, &c.
Lingulina carinata, d'Orbigny, 1826, Ann. Sci. Nat.. vol. vii. p. 257, No. 1;—Modèle, No. 26.
" " Id. 1839, Foram. Canaries, p. 124, pl. i. figs. 5, 6.
" " Williamson, 1858, Rec. For. Gt. Br., p. 14, pl. ii. figs. 33–35.

Neither of the drawings on Pl. LXV. illustrates satisfactorily the typical characters of this species. Figure 16 represents an intermediate form, the later segments of which are only slightly compressed, altogether but little removed from the true *Nodosariæ;* and fig. 17 is a short specimen, with an unusually large primordial chamber, the oral end of which is armed with a pair of small marginal spines—the latter an anomalous feature. Excellent figures of the species, from recent specimens, are given by d'Orbigny and by Williamson in the works above referred to.

The Challenger material has yielded very few examples of *Lingulina carinata*, as distinct from the subcostate modification (var. *seminuda*), and only from the following Stations:—off Ki Islands 580 fathoms; off Honolulu coral-reefs, 40 fathoms; and off Nightingale Island, Tristan d'Acunha, 100 to 150 fathoms. It has, however, been found in shore-sand from Teneriffe, and from the West Indies (d'Orbigny); in soundings

from the Mediterranean, 90 fathoms to 250 fathoms, and in shore-sand from the Adriatic (Parker and Jones); and in shallow-water dredgings from the British seas (Williamson, Balkwill and Wright).

As a fossil, it has been recorded from the Lias of the west of England (Brady), the Chalk of Kent (Rupert Jones) and of Ireland (Wright), and the later Tertiary deposits of Italy (Soldani, Parker and Jones, Seguenza).

Lingulina carinata, var. *seminuda*, Hantken (Pl. LXV. figs. 14, 15).

Lingulina costata, var. *seminuda*,[1] Hantken, 1875, Mittheil. Jahrb. d. k. ungar. geol. Anstalt, vol. iv. p. 41, pl. iv. fig. 8, *a.b.*

The large *Lingulinæ*, not uncommon in certain areas of the North Atlantic, are seldom really carinate, but the lateral edges of the test are slightly rounded, and each margin is ornamented with a few delicate longitudinal ribs. With this exception the lateral faces are smooth.

Fossil specimens similarly characterised are described by von Hantken as constituting a variety of *Lingulina costata*; but as that species is unknown in the recent condition, and as broad unornamented modifications of *Lingulina carinata* (*Lingulina glabra*, Hantken) are found in the same formations, it is more probable that their relationship is with the typical form. Living examples of *Lingulina carinata*, var. *seminuda*, often attain large dimensions, sometimes as much as $\frac{1}{6}$th to $\frac{1}{4}$th inch (4 to 6 mm.) in length.

This variety has been observed at six Stations in the North Atlantic, at depths between 390 fathoms and 862 fathoms; at two in the South Atlantic, not far from Pernambuco, 350 fathoms and 675 fathoms respectively; and in the Mediterranean, 1200 fathoms. The finest Challenger specimens are those from Station 24, off Culebra Island, West Indies, 390 fathoms, and Station 75, off the Azores, 450 fathoms.

Von Hantken records its occurrence in the Upper and Lower *Clavulina-szabói* formations of Ofen (Buda), Hungary, and in the "Priabona-Schichten" of Italy.

Frondicularia, Defrance.

Nautilus (*Orthoceras*), pars, Batsch [1791].
Orthoceras, pars, Soldani [1798].
Frondicularia, Defrance [1824], Blainville, d'Orbigny, Bronn, Hagenow, Reuss, Bornemann, Williamson, Terquem, Parker and Jones, Carpenter, Neugeboren, Karrer, &c.
Renulina, pars, Blainville [1825].
Planularia, Nilsson [1827], Hisinger, Münster.
Frondiculina (Münster), Römer [1838].
Textularia, pars, Potiez and Michaud [1838].

The genus *Frondicularia* bears the same morphological relation to *Lingulina* that *Glandulina* bears to *Nodosaria* proper, and the boundary-line in the former case is

[1] In the explanation of plate iv. of Hantken's memoir, the name is written *Lingulina costata*, var. *subglabra*.

nearly as indistinct and theoretical as in the latter. *Lingulina* and *Frondicularia* form a continuous series, including the compressed and complanate straight *Nodosarinæ*. To the former genus are assigned those forms which have directly transverse or arched septa, to the latter those in which the segments are bent in a greater degree. The extent to which the segments are reflexed varies with almost every species. In what may be looked upon as the typical Frondicularian shell, that in which the generic peculiarities are developed the most fully, the chambers are prolonged backwards at the two sides so far that each encloses the whole, or almost the whole, of its predecessor.

The surface of the test is either smooth or has a superficial ornament of longitudinal striæ or costæ, either continuous or interrupted; and occasionally the sutures are marked by raised lines of shelly deposit.

The genus *Frondicularia* is subject to dimorphous modification in two ways. Sometimes the earlier chambers are developed on one side only, so that the shell has a planospiral or Cristellarian commencement, whilst the later segments take the normal shape and arrangement. Such varieties constitute the subgenus *Flabellina*. On the other hand, the early segments may be Frondicularian and the later ones cylindrical or Nodosarian, and these forms have been distinguished under the subgeneric name *Amphimorphina*.

Recent *Frondiculariæ* are exceedingly rare. If we except a comparatively small area in the western portion of the Atlantic, from the West Indies northward to Bermuda, and a limited region of the Indian Archipelago, south-west of Papua, it is impossible to name any ground on which hitherto more than a chance specimen or two has been met with. The depth of water which the genus most affects appears to be from 80 to 600 fathoms. As a fossil type *Frondicularia* is much more adundant, and its range in geological time extends from the Trias to the later portion of the Tertiary epoch.

Frondicularia spathulata, H. B. Brady (Pl. LXV. fig. 18).

Frondicularia spathulata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 56, pl. viii. fig. 5, *a.b.*

Test elongate, narrow, tapering, compressed; lateral edges rounded and somewhat lobulate; segments numerous; sutures slightly excavated. Primordial segment inflated; those immediately following it more reflexed than the later chambers, which are only slightly curved. Surface smooth. Length, $\frac{1}{45}$th inch (0·56 mm.).

This is one of the narrow compressed Nodosarian shells that might with almost equal propriety be placed either with *Lingulina* or *Frondicularia*, the slightly inflated primordial chamber and bent earlier segments suggesting somewhat greater affinity to the latter genus.

Terquem figures a similar form as *Frondicularia sacculus* (Foram. du Lias, 6ième mém., p. 482, pl. xix. fig. 20, *a.b.*); and the *Frondicularia linearis* of Philippi (Beitr. zur Kennt. d. Tert.-Verstein., p. 5, pl. i. fig. 32) is a Flabelline variety, with analogous general contour.

Such organisms are very rare in the living condition, and the present species has only been obtained at two Challenger Stations, namely,—off the Ki Islands, 129 fathoms, and off Raine Island, 155 fathoms. Mr. F. W. Millett has the same form from the coast of the Korea, 40 fathoms.

Frondicularia archiaciana, d'Orbigny (Pl. CXIV. fig. 12).

Frondicularia archiaciana, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. p. 20, pl. i. figs. 34–36.
„ „ Reuss, 1845, Verstein. böhm. Kreid., pt. 1, p. 31, pl. xiii. fig. 39, *a.b.*
„ „ Williamson, 1858, Rec. For. Gt. Br., p. 23, pl. ii. fig. 51.
„ *tenuis*, Reuss, 1874, Das Elbthalgebirge in Sachsen, 2 Th., p. 94, pl. xxi. fig. 3.

The beautiful elongate *Frondicularia* (Pl. CXIV. fig. 12) belongs, I think, to this species. The contour of the shell is almost precisely that of d'Orbigny's drawing, though the rudimentary costæ on the small, inflated, primordial segment are wanting. Very similar forms are described by Reuss, under the name *Frondicularia canaliculata* (Sitz. d. k. Ak. Wiss. Wien, vol. xl. p. 194, pl. vi. fig. 1), and by Karrer, as *Frondicularia amœna* (Jahrb. d. k. geol. Reichsanst., 1870, p. 172, pl. x. fig. 10), but both are somewhat broader near the distal end, and more tapering in outline.

The recent specimen was obtained from the rich dredging off Raine Island, Torres Strait, 155 fathoms.

Frondicularia archiaciana is a common Cretaceous species. A slightly broken specimen, found in shore-sand from Sandwich, Kent, is figured by Williamson amongst recent forms; but there can be little doubt that the original was a fossil, washed from the chalk cliffs of the neighbouring coast-line.

Frondicularia compta, H. B. Brady (Pl. LXV. fig. 19).

Frondicularia compta, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 57, pl. viii. fig. 6.

Test long, complanate, spathulate; truncate or emarginate at the base, obtusely angular at the distal end; lateral edges square, more or less lobulate. Early segments larger than those subsequently formed, sutural lines limbate; surface otherwise smooth. Length, $\frac{1}{25}$th inch (1 mm.).

A very beautiful little shell, with just sufficient irregularity of structure to render it difficult of description in brief or definite terms, and equally difficult to reconcile with

previously recorded species. The earlier portion of the test is built on a bolder, larger plan than the rest, and the septal lines are thickened and raised. The later segments are relatively narrow and small, possibly starved by some sudden alteration of habitat, and the sutures, though still limbate, are not so prominent.

The figured specimen was found in sand dredged off East Moncœur Island, Bass Strait, depth 38 fathoms.

Frondicularia inæqualis, Costa (Pl. LXVI. figs. 8–12).

Frondicularia inæqualis, Costa, 1855, Mem. Accad. Sci. Napoli, vol. ii. p. 372, pl. iii. fig. 3.
„ *compressa*, Id. Ibid. p. 372, pl. iii. fig. 2.
„ *whaingaroica*, Stache, 1864, Novara-Exped., geol. Theil, vol. i. p. 210, pl. xxii. fig. 43, *a.b.*
„ *foliacea*, Schwager, 1866, Ibid. vol. ii. p. 236, pl. vi. fig 76.
„ *medelingensis*, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 380, pl. xvi. *b.*, fig. 25.
Flabellina foliacea, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 57, pl. viii. figs. 8–10.

In the preliminary description of the recent specimens, this species was referred to the dimorphous genus *Flabellina*, though its close affinity to the *Frondicularia foliacea* of Schwager was at the same time fully stated. The position to which it was assigned was due to the irregularity of the earlier segments and their almost invariably inequilateral arrangement. Additional specimens have since been found, which tend to show that the species has an even greater range of variability than was at first recognised; and a further examination of the series has led to the conclusion that, though often unsymmetrical both in contour and disposition, the initial chambers are not in any strict sense Cristellarian, and hence that the form may properly be retained amongst the typical *Frondiculariæ*. A careful comparison of the figures of *Frondicularia inæqualis*, *Frondicularia compressa*, *Frondicularia whaingaroica*, *Frondicularia foliacea*, *Frondicularia medelingensis* with each other and with the drawings from living specimens now furnished, brings an irresistible conviction that they all represent mere individual modifications of one polymorphic species. In the recent condition the shell is seldom ound entire, owing to its thin and fragile character, but even small fragments are easily dentified.

Frondicularia inæqualis has been found in sands dredged at six Challenger Stations, namely:—at two points near the Ki Islands, depth 129 fathoms and 580 fathoms respectively; off Raine Island, Torres Strait, 155 fathoms; off the west coast of New Zealand, 275 fathoms; off the Cape of Good Hope, 150 fathoms; and off the coast of North America, south-east of New York, 1240 fathoms.

The fossil specimens above referred to were obtained from deposits of Miocene and Pliocene age, in various parts of the world.

Frondicularia alata, d'Orbigny (Pl. LXV. figs. 20–23; Flabelline variety, Pl. LXVI. figs. 3–5).

"Nautili *caudiformes*," Soldani, 1798, Testaceographia, vol. ii. p. 13, pl. i. fig. *C*.
Frondicularia alata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 256, No. 2.
" " Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 161, pl. x. fig. 66.
" *alata*, var. *sagittula*, Vanden Broeck, 1876, Ann. Soc. Belg. Micr., vol. ii. p. 113, pl. ii. figs. 12, 14.
" " var. *lanceolata*, Id. Ibid. p. 117, pl. ii. fig. 13.
" *complanata*, var. *concinna*, Id. Ibid. p. 109, pl. iii. fig. 2.

The figure in the Testaceographia, selected by d'Orbigny to bear the name *Frondicularia alata*, is that of a short complanate shell, which is very broad near the initial end, owing to the arms of the V-shaped segments reaching back nearly into a line with the primordial chamber. The free ends of the segments are irregular, and most of them projecting and pointed. The drawing is somewhat rough, but represents in their extreme development characters easily recognised in more typical specimens.

Referring to the illustrations, the two larger figures (figs. 20, 21) represent good examples of the species in the adult condition, the free ends of the chambers forming a nearly straight line, and one here and there extended into a projecting point. Such shells attain large dimensions, the length sometimes exceeding $\frac{1}{5}$th inch (5 mm.). Vanden Broeck (*loc. cit.*) gives an excellent series of drawings, representing individual modifications of the species rather than distinct varieties.

In the immature or arrested stage the outline is less angular, and the test assumes the more or less ovate contour displayed in figures 22 and 23, resembling in this respect the typical *Frondicularia complanata* of Defrance, as depicted by Blainville (Malacologie, pl. vi. figs. 4, 4*a*).

Amongst the West Indian specimens there are a considerable proportion of dimorphous shells (Pl. LXVI. figs. 3–5), which, had they been found alone or in different company, must have been classed as *Flabellinæ*. Excepting the inequilateral growth of a few of their earlier segments, a feature in which no two of them are alike, they agree in every respect with the more typical specimens; indeed it is perfectly evident, when a number are examined together, that they are mere anomalous individuals of the same species.

The distribution of *Frondicularia alata* as a recent Foraminifer, so far as at present known, is limited to a few localities. The Challenger collections furnish specimens from off Culebra Island, 390 fathoms, and off Bermuda, 435 fathoms; and those recorded by Vanden Broeck were from near Barbados, 84 fathoms (100 brasses). The habitat given by d'Orbigny, both for *Frondicularia alata* and *Frondicularia rhomboidalis* (Modèle, No. 3), is the Adriatic; and some years ago Dr. Tiberi of Portici sent to me for identification some fine recent examples of both of these species, found in shore-sand from near Magnisi, on the east coast of Sicily.

Soldani states that fossil specimens occur in the Subapennine Tertiaries near Sienna.

Frondicularia interrupta, Karrer (Pl. LXVI. figs. 6, 7).

Frondicularia interrupta, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 380, pl. xvi. *b*. fig. 27.
Flabellina cuneata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 57, pl. viii. fig. 7.

The specimens represented by figs. 6, 7, were originally assigned, with some reservation on account of their greater regularity of form and structure, to the *Flabellina cuneata* of Münster (Neues Jahrb. für Min., &c., 1838, p. 383, pl. iii. fig. 10); and so far as can be made out from the small and exceedingly indistinct figure furnished by Roemer in the memoir referred to, that species differs in little except its dimorphous mode of growth from the recent shells.

Nevertheless, strictly speaking, the living specimens have more affinity with the typical *Frondiculariæ* than with the dimorphous group, and an alternative is offered in the form described by Karrer, under the name *Frondicularia interrupta*, which presents almost identical features. The same author has also figured another and closely allied variety, *Frondicularia antonina* (Geol. von Luzon, p. 91, pl. v. fig. 14), distinguished from the foregoing chiefly by the continuity of the superficial striæ and their somewhat closer setting. In these particulars one of the recent shells (fig. 7) exhibits intermediate characters.

The habitat of the recent specimens is,—off the Ki Islands, south-west of New Guinea, depth, 129 fathoms.

The fossil shells originally described were from the Miocene of Baden near Vienna.

Frondicularia robusta, n. sp. (Pl. LXVI. figs. 1, 2).

Test elongate, compressed, stoutly built; lateral margins nearly parallel, ends obtusely angular or rounded, peripheral edges thick, rounded, slightly lobulated. Segments numerous; nearly uniform in size after the initial stage, somewhat irregular in contour, comparatively little bent. Surface furnished with closely set, irregular or interrupted, longitudinal costæ. Length, $\frac{1}{7}$th inch (3·6 mm.).

This is a large and striking species, distinguished from most of its congeners by the unusually thick and solid proportions of the test. The form of the segments approaches that of the *Lingulinæ;* instead of being reflexed at a sharp angle from the median line, in the normal way, they are obtusely bent, and the apertural end of each segment is blunt and rounded. The superficial ornament is less regular than is customary amongst the *Nodosarinæ*.

Frondicularia robusta has only been found at two localities:—off the Ki Islands, south-west of Papua, 129 fathoms; and on the coral-reefs of Honolulu, Sandwich Islands, 40 fathoms.

Frondicularia millettii, n. sp. (woodcut, fig. 16, *a.b.*).

Test elongate, tapering, compressed; oral end broad and rounded, aboral extremity obtusely pointed; lateral faces concave; peripheral edges thick and rounded, and ornamented with numerous, raised, parallel, longitudinal costæ; aperture a simple, circular, bordered orifice. Segments about ten in number; sutures marked by very slight depressions. Length, $\frac{1}{70}$th inch (0·36 mm.) or more.

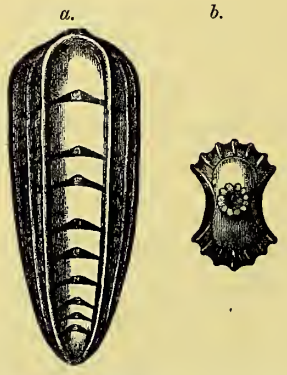

Fig. 16. — *Frondicularia millettii*, n. sp.; magnified 120 diameters.
a. Side view.
b. End view, showing the aperture.

This beautiful little shell appears almost equally related to *Frondicularia* and *Lingulina*, and in the absence of any more distinctive feature, the shape of the aperture has suggested its nearer affinity to the former genus. The concave faces and thick, round, costate edges are sufficient for its easy identification.

The specimen from which the woodcut has been drawn was sent to me by my friend Mr. F. W. Millett, by whom it was obtained from the coral-sand dredged at Station 185, off Raine Island, 155 fathoms; and I have much pleasure in associating his name with the species.

Rhabdogonium, Reuss.

Vaginulina, pars, d'Orbigny [1826], Parker, Jones, and Brady.
Orthocerina, pars, d'Orbigny [1839], Carpenter, Blake, Bütschli.
Triplasia, Reuss [1854], Costa.
Rhabdogonium, Reuss [1860], Karrer, Gümbel, Hantken, Terquem, Schwager, Brady.

The genus *Orthocerina* was included by d'Orbigny in the "Tableau Méthodique,"[1] and characterised by the possession of a straight conical test having cylindrical tapering chambers, but without any terminal prolongation for the aperture, that is to say, with an orifice situated on the truncate or convex face of the final segment. The genus was then limited to a single species, *Nodosaria* (*Orthocerina*) *clavulus*, a fossil from the Paris Tertiaries, and upon this Modèle No. 2 is founded. The particular form intended to be represented by the model in question cannot now be identified, unless, as suggested by Parker and Jones, it is one of the Tertiary *Clavulinæ* which has lost its valvular tongue —an explanation that appears in every way probable.

In 1839 (Foram. Cuba, p. 47), a four-sided species, *Orthocerina quadrilatera*, was added to the genus, and the distinctive characters were modified so far as to include angular as well as cylindrical varieties, the terms referring to the aperture being retained without alteration; and the same description was repeated in 1846, in the "Vienna Basin" monograph.

[1] In the first instance the term was employed in a subgeneric sense for the 4th section of the *Nodosariæ*.

In 1854 Reuss introduced the generic term *Triplasia* for the three-sided *Nodosarinæ* of the Cretaceous formations; but subsequently, in 1860, having found quadrangular as well as triangular forms, this name was changed to *Rhabdogonium*.

The question to be determined is whether d'Orbigny's name or Reuss's—*Orthocerina* or *Rhabdogonium*—should now be adopted. Of the generic group, as now understood, there can be no doubt that the species which first received a name was d'Orbigny's *Vaginulina tricarinata;* and it is equally certain that, of the two species for which the term *Orthocerina* was used, the earlier in point of date, that which was subsequently referred to by the author as the typical form, does not belong to the present genus; and further that the recorded characters, if intended for the forms under consideration, which is by no means clear, are far from accurate. Add to this the fact that a number of almost identical generic names, *Orthocera*, *Orthoceras*, *Orthoceratium*, and others, were in general use, and had been applied to almost every variety of cylindrical or moniliform Foraminifera before *Orthocerina* was proposed, and the desirability of accepting the later term becomes manifest.

The genus *Rhabdogonium* differs from *Nodosaria* primarily in the angular contour of the test. The shell is straight or only slightly bent, usually triangular or quadrangular in section, the salient edges being sometimes carinate. The segments are convex and compactly fitted together, their angular margins are somewhat drawn down towards the primordial end of the test, and there is little or no external constriction at the sutures. The aperture is a simple circular orifice at the centre of the somewhat tapering or produced end of the final segment, sometimes situated in a short neck.

The genus is widely distributed, especially in the North Atlantic and the South Pacific; in the former it is usually found at depths of more than 300 fathoms, in the latter almost invariably at less than 300 fathoms. It occurs sparingly in the South Atlantic, but, so far as has been observed, is entirely wanting in the North Pacific. Geologically speaking, the genus makes its first appearance in the Lias, and becomes tolerably abundant in the Cretaceous period; it is met with also in various Tertiary deposits, but not as a prevailing type.

Rhabdogonium tricarinatum, d'Orbigny, sp. (Pl. LXVII. figs. 1–3).

Vaginulina tricarinata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 258, No. 4,—Modèle, No. 4.
Rhabdogonium pyramidale, Karrer, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xvi. p. 19, pl. i. fig. 34.

D'Orbigny's Modèle, No. 4, though easily recognised, is not a satisfactory rendering of the characters of this species. In the model the oral end of the test is truncate and the aperture a simple perforation placed in one of the angles, at no great distance from the margin. Such specimens may sometimes occur, but far more commonly the test

tapers almost equally towards either end, and the aperture is nearly central, and situated in a slightly produced neck; the entire shell is sometimes gently curved or twisted.

Rhabdogonium tricarinatum is common in the North Atlantic, and out of nine localities at which it has been taken, eight range between 390 fathoms and 1360 fathoms, whilst the ninth is in comparatively shallow water, near the west coast of Ireland. In the South Atlantic it has been observed at two Stations near Pernambuco, 350 fathoms and 675 fathoms respectively; and in the South Pacific at eight Stations, the depth of which varies from 12 fathoms to 275 fathoms. It has not been noticed at any point in the North Pacific. D'Orbigny's specimens were from the Adriatic, and a few examples have been obtained from the Mediterranean.

The species has been found in the Miocene of Baden near Vienna (Karrer), in the Subapennine Tertiary shell-sands of Italy, and in a clay of Later Tertiary age in the neighbourhood of Malaga (Parker and Jones).

Rhabdogonium minutum, Reuss (Pl. LXVII. figs. 4–6).

Rhabdogonium minutum, Reuss, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 84, pl. v. figs. 4, 5.

The specimens portrayed in figs. 4–6 are of stout and somewhat irregular contour; the walls are thick and wanting in finish, and the margins show a tendency to become carinate. Such shells seldom consist of more than three or four segments. Very similar peculiarities are exhibited by *Rhabdogonium minutum*, as figured by Reuss; and although the term "*minutum*" scarcely applies to the recent examples, as compared with their congeners, they may in other respects be fitly assigned to that species.

This form has only been observed in one locality,—off Ki Islands, south-west of New Guinea, 129 fathoms.

Reuss's fossil specimens were from the Salt-clay of Wieliczka, in Galicia.

Marginulina, d'Orbigny.

Nautilus, pars, Linné [1767], Walker.
Orthocera, *Orthoceras*, seu *Orthoceratium*, pars, Soldani [1791], Lamarck, Defrance, Blainville.
Marginulina, d'Orbigny [1826], Bronn, Roemer, Philippi, Reuss, Czjzek, Cornuel, Bailey, Bornemann, Costa, Neugeboren, Terquem, Parker and Jones, &c.
Cristellaria, pars, Williamson [1858], Seguenza, Berthelin, &c.

The descriptive characters of the genus *Marginulina*, as furnished by d'Orbigny in the "Tableau Méthodique," are brief and insufficient; but it is manifest from the various figures referred to in the enumeration of species, that it was intended to include only the subcylindrical as distinct from the compressed forms of *Nodosarinæ*; and the fuller description subsequently given in the "Vienna Basin" Monograph, in which the globular shape of the segments is expressly mentioned, confirms this view.

The test of *Marginulina* is curved or nearly straight, sometimes slightly helicoid at the commencement; the linear portion is round or nearly so in transverse section, and the later segments are generally subglobular. The aperture is marginal and either simple or slightly radiate. Morphologically the genus stands midway between the Dentaline varieties of *Nodosaria* and the longer forms of *Cristellaria;* whilst it differs from *Vaginulina* chiefly by the absence of any marked lateral compression. At best the position is very ill defined, and the vague sense in which the generic term has not unfrequently been employed has been a source of much confusion of nomenclature.

The genus *Marginulina* is very widely diffused, being found in one form or other in all the great oceans and at almost every depth; but as compared with the allied genera, it is nowhere abundant. As a fossil it makes its earliest appearance in the Lower Lias, and it occurs in microzoic rocks of almost every subsequent geological age.

Marginulina glabra, d'Orbigny (Pl. LXV. figs. 5, 6).

Marginulina glabra, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 259, No. 6;—Modèle, No. 55.
„ *elongata*, Id. 1840, Mém. Soc. géol. France, vol. iv. p. 17, pl. i. fig. 22.
„ *pedum*, Id. 1846, For. Foss. Vien., p. 68, pl. iii. figs. 13, 14.
„ *similis*, Id. Ibid. p. 69, pl. iii. figs. 15, 16.
„ *pediformis*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 326, pl. xiii. fig. 13.
„ *contracta*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 186, pl. xiii. fig. 10.
„ *abbreviata*, Karrer, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 445, pl. i. fig. 7.
„ *inæqualis*, Reuss, 1862, Ibid. vol. xlvi. p. 59, pl. v. fig. 13.
„ *infarcta*, Id. 1863, Ibid. vol. xlviii. p. 48, pl. iii. figs. 36, 37.
„ *opaca*, Stache, 1864, Novara-Exped., geol. Theil, vol. i. pt. 2, p. 214, pl. xxii. fig. 47.
„ *angistoma*, Id. Ibid. p. 213, pl. xxii. fig. 46.
„ *mucronulata*, Id. Ibid. p. 215, pl. xxii. fig. 48.
„ *glabra*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 27, pl. i. fig. 36.
„ „ Brady, 1867, Proc. Somerset. Arch. and Nat. Hist. Soc., vol. xiii. p. 109, pl. ii. fig. 22.
, *subbullata*, Hantken, 1875, Mittheil. Jahrb. d. k. ungar. geol. Anstalt, vol. iv. p. 46, pl. iv. figs. 9, 10.
„ *splendens*, Id. Ibid. p. 87, pl. iv. fig. 11.
„ *pediformis*, Id. Ibid. p. 45, pl. iv. figs. 12, 13; pl. v. fig. 8.
Cristellaria articulata, Seguenza, 1880, Atti. R. Accad. dei Lincei, ser. 3, vol vi. p. 140, pl. xiii. figs. 10, 10*a*.
„ *trunculata*, Berthelin, 1880, Mém. Soc. géol. France, sér. 3, vol. i., Mém. v. p. 53, pl. iii. figs. 26, 27.

D'Orbigny's Model, No. 55, forms an excellent central type of this species. It represents a short, somewhat tapering, Nodosariform shell, curved near the initial end

and nearly circular in transverse section. The length is equal to about three times the width of the final segment; it has six chambers, all slightly inflated, and the last is large in comparison with the others. The aperture is produced and marginal, and the aboral end of the test finishes in a blunt rounded point.

The proportionate length and breadth of the shell is a character open to constant variation, and the specimens from which figs. 5 and 6 have been drawn are too short and stout, and the segments too little inflated to be quite typical; nevertheless they form links of a series too closely connected for subdivision on the basis of minute differences of contour. The figures referred to in the foregoing long array of synonyms exhibit a certain amount of diversity of form. Some of them represent shells of similar outline to the original model, others specimens of stouter build, more like the drawings on Pl. LXV.; but it would be very easy to increase the list without transgressing the legitimate bounds of the species.

Marginulina glabra has been found in shallow water on the British coast, and at various depths down to 2740 fathoms in the North Atlantic; it occurs also in deep water in the Mediterranean. The Challenger collections have furnished specimens from two Stations in the South Atlantic, 420 fathoms and 2350 fathoms; from nine Stations in the South Pacific, 15 fathoms to 1100 fathoms; and from two in the North Pacific, 345 fathoms and 2150 fathoms respectively.

In the fossil condition, its presence has been recorded, under one name or other, in the Middle and Upper Lias of England, in the Cretaceous formations of Ireland, France, Germany, and Bohemia; in the Septaria-clays of Germany, in the *Clavulina-szabói* beds of Hungary, in the Miocene deposits of the Vienna Basin, in the later Tertiaries of Italy, and in the Crag of Suffolk.

Marginulina costata, Batsch, sp. (Pl. LXV. figs. 10–13).

Nautilus (*Orthoceras*) *costatus*, Batsch, 1791, Conchyl. des Seesandes, p. 2, pl. i. fig. 1, *a–g*.
" Orthoceratia, *Raphanus*, *Raphanistrum*, et *Rapistrum*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 91, pl. xciv. figs. *N*, *P*, *Q*, *R*, *X*, *Y*.
Marginulina raphanus, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 258, No. 1, pl. x. figs. 7, 8;—Modèle, No. 6.
„ *interamniæ*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 184, pl. xiii. fig. 9.
„ *obliquestriata*, Karrer, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 446, pl. i. fig. 8.
„ *striatocostata*, Reuss, 1862, Ibid. vol. xlvi. p. 62, pl. vi. fig. 2.
„ *turgida*, Id. Ibid. p. 63, pl. vi. fig. 7.
„ *raphanus*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 19, pl. i. fig. 35.
„ *hamus*, Terquem, 1866, Foram. du Lias, 6ième Mém., p. 501, pl. xxi. fig. 8, *a,b*.
„ *radiata*, Id. Ibid. p. 505, pl. xxi. figs. 16, 17.
„ *raphanus*, var. *crebicosta*, Seguenza, 1880, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 90, pl. ix. fig. 6.

This species, of which the earliest available description and figures are those given by Batsch in 1791, is the best representative of the costate varieties of *Marginulina*. Individual specimens vary a good deal in contour, and also as to the number and degree of development of the superficial ribs; but the stout proportions of the shell, its subcylindrical form and comparatively slight curvature, the inflated character of the later chambers, and the marginal aperture, are generally sufficient to distinguish it from costate varieties of *Vaginulina* and *Cristellaria*. The test is often more or less compressed just at the commencement, and occasionally presents a sharp or even subcarinate edge at the aboral end, but more frequently the margin is rounded from the beginning.

Starved, thin-shelled specimens of *Marginulina costata* have been found from time to time in the British seas, though they are of rare occurrence. In its fully developed condition, the species has been obtained from various parts of the North Atlantic, at depths of from 370 fathoms to 1240 fathoms; from the South Atlantic at still greater depths; from the Mediterranean, and from the Adriatic. Except a few small ill-characterised examples, taken at a depth of 150 fathoms off the coast of New Zealand, it has not been observed in either the North or South Pacific, the Southern Ocean, or the Red Sea.

Fossil specimens have been described, under a number of different names, from the Liassic marls of England, Ireland, and France; the Kimmeridge Clay; the Cretaceous formations of Ireland and Germany; the Miocene beds of Austria; the later Tertiaries of Italy and Spain, and the Crag of the Eastern Counties.

Vaginulina, d'Orbigny.

"Cornu Hammonis," Plancus [1739].

Orthocera, *Orthoceras*, seu *Orthoceratium*, pars, Gaultieri [1742], Soldani, Batsch, Lamarck, Defrance.

Nautilus, pars, Linné [1767], Batsch, Walker, Montagu, Dillwyn.

Planularia, Defrance [1824], Blainville, d'Orbigny, Cornuel, Parker and Jones, Brady, Blake, Walford.

Vaginulina, d'Orbigny [1826], Roemer, Michelotti, Philippi, Reuss, Bornemann, Neugeboren, Costa, Parker and Jones, Gümbel, Karrer, Seguenza, &c.

Citharina, d'Orbigny [1839], Reuss.

Marginulina, pars, Reuss [1851], Terquem.

Dentalina, pars, Williamson [1858], Parfitt.

The *quasi*-generic term *Vaginulina* may be conveniently adopted for those compressed and complanate varieties of *Nodosarinæ* which have oblique segments and a marginal aperture. Such forms are generally somewhat curved or arcuate, and taken collectively they are almost equally related to the Dentaline *Nodosariæ*, the *Marginulinæ*, and the ensiform modifications of *Cristellaria*. No sharp lines of demarcation can be drawn between these allied groups; but in general terms it may be said that *Vaginulina* is distinguished from *Marginulina* by its more or less flattened contour, from the curved

Nodosariæ by its compressed form and broader outline, as well as by its marginal aperture, and from the elongate *Cristellariæ* by the absence of spiral arrangement in its very early segments.

No good end appears to be gained by the retention of Defrance's genus *Planularia*. The term, as employed by d'Orbigny, Cornuel, and others, included a number of complanate *Nodosarinæ*, differing from the more typical *Vaginulinæ* chiefly, if not solely, in their greater degree of lateral compression; together with a few forms with spiral commencement, more properly classed amongst *Cristellariæ*.

The genus *Vaginulina* is very widely distributed. In one form or other it is met with in all the great oceans, in the Mediterranean, and in the Adriatic; but it is only in the North Atlantic that it is a prevailing type. Its geological range extends as far back as the Upper Trias; it is common in the Lias and Oolite, and has been found in marine sedimentary rocks of almost every succeeding age to the present time.

Vaginulina legumen, Linné, sp. (Pl. LXVI. figs. 13–15).

Nautilus legumen, Linné, 1758, Syst. Nat., 10th ed., p. 711, No. 248;—1767, 12th ed., p. 1164, No. 288.
Nautilus (*Orthoceras*) *legumini formis*, Batsch, 1791, Conchyl. des Seesandes, No. 8, pl. iii. fig. 8, *a*.
Vaginulina legumen, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 257, No. 2.
Vaginulina lævigata, Roemer, 1838, Neues Jahrb. für Min. &c., p. 383, pl. iii. fig. 11.
Dentalina legumen, Williamson, 1858, Rec. For. Gt. Br., p. 21, pl. ii. fig. 45.
Vaginulina legumen, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag., p. 64, pl. iv. fig. 9.

It appears best to accept the earliest specific appellation, that used by Linné in the "Systema Naturæ," for the typical smooth forms of the genus. It is employed in this sense by Williamson, and also apparently by d'Orbigny, who attributes to a distinct species, *Vaginulina elegans*, the varieties which have limbate sutures. With this limitation, *Vaginulina legumen* is characterised by the nearly straight, pod-like contour of the test, and the non-spiral arrangement of the segments. Individual specimens differ amongst themselves in their relative length, width, and degree of compression; in other respects they present tolerably uniform features. The septa are often thick and transparent, without being limbate externally. It is impossible to draw any definite line of separation between the smooth *Vaginulinæ* and the ensiform varieties of *Cristellaria*.

Vaginulina legumen is a cosmopolitan species, living at every depth down to 2000 fathoms or more. It is commonest in shallow water, the smooth forms being often associated with the limbate and costate varieties.

In the fossil condition it occurs as far back as the Trias; it is found also in the Lias, and, associated with other *Nodosarinæ*, in many later deposits of Secondary and Tertiary age.

Vaginulina legumen, var. *arquata*, nov. (Pl. CXIV. fig. 13).

Over a considerable area of the North Atlantic, at depths of less than 1000 fathoms, there occurs a variety of *Vaginulina legumen* characterised primarily by its peculiar arched contour and its very large dimensions. The test is sometimes half an inch in length and proportionately broad; it is quite smooth externally, and the septa, especially in very large specimens, are often scarcely visible, owing to the thickness and opacity of the shell-wall.

This variety is one of a series, of which the shell figured by Parker and Jones under the name *Marginulina lituus* (Phil. Trans., vol. clv., pl. xiii. fig. 14, *a.b.*) exemplifies another stage, connecting the typical *Vaginulinæ* with *Cristellaria compressa* and the allied forms.

Vaginulina spinigera, H. B. Brady (Pl. LXVII. figs. 13, 14).

Marginulina, sp., Whiteaves, 1872, Report Brit. Assoc., Brighton Meeting, Trans., p. 144.
Vaginulina spinigera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 63.

Test short and broad, as compared with typical specimens of *Vaginulina legumen;* compressed and somewhat tapering; terminating at the primordial end in two (rarely three or more) long stout spines, one of which is usually in a line with the main axis of the shell, whilst the others radiate at various angles. Length of the shell without the spines, about $\frac{1}{7}$th inch (3·6 mm.), the spines often about two-thirds as long, or even occasionally as long as the body of the test.

Mr. Whiteaves has accurately described this striking Foraminifer (*loc. cit.*), referring it to the genus *Marginulina*, but without giving it a specific name. The name *Marginulina spinosa* appears in one of the lists of the marine fauna of the coast of Norway published by the late Prof. M. Sars,[1] but as it is unaccompanied by either description or figure it can only be surmised that it may possibly be intended for the same form. With reference to the generic affinity of the species it may be observed that the test is always a good deal compressed, and therefore so far as the distinction between *Vaginulina* and *Marginulina* is of any value, the species belongs to the former rather than the latter genus.

Vaginulina spinigera is not uncommon in the North Atlantic, north of lat. 45° N., at depths ranging from 100 to 1200 fathoms. In the Challenger collections it is exceedingly rare, but single specimens have been obtained from three Stations, namely:—off the coast of South America, near Pernambuco, 675 fathoms; off Sydney, New South Wales, 410 fathoms; and off the Ki Islands, 580 fathoms.

[1] *Videnskab.-Selsk. Forhandlinger*, 1868, p. 248.

Vaginulina margaritifera, Batsch, sp. (Pl. LXVI. fig. 16).

Nautilus (*Orthoceras*) *margaritiferus*, Batsch, 1791, Conchyl. des Seesandes, p. 3, pl. iv. fig. 12, *a–c*.
Vaginulina elegans, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 257, No. 1 ;—Modèle, No. 54.
„ *ligata*, Reuss, 1864, Sitzungsb. d. k. Ak. Wiss. Wien, vol. l. p. 457, pl. i. fig. 11.
„ *italica*, Costa, 1855, Mem. Accad. Sci. Napoli, vol. ii. p. 145, pl. ii. fig. 15.

Batsch's *Nautilus margaritiferus* leaves nothing to be desired as a representative of those varieties of *Vaginulina legumen* which have the septal lines thickened and embossed by exogenous deposit of clear shell-substance. The group is equally well typified by d'Orbigny's Modèle No. 54, *Vaginulina elegans*, but the former name has the priority. The primordial chamber of such specimens is frequently armed with a stout spine, as shown in Costa's figure (*loc. cit.*)

Neither in the recent nor the fossil condition are the limbate varieties of the genus so common as those with non-limbate sutures. The former seldom occur except in company with the typical *Vaginulina legumen*, and there are no data by which their separate distribution can be satisfactorily determined.

Vaginulina bruckenthali, Neugeboren (Pl. LXVI. figs. 18, 19).

Vaginulina bruckenthali, Neugeboren, 1856, Denkschr. d. k. Akad. Wiss. Wien, vol. xii. p. 98, pl. v. fig. 10, *a–d*.

The broad compressed specimens, figs. 18, 19, with thick clear septal lines, and with one or, more frequently, two short pointed spines at the primordial end, correspond well with Neugeboren's drawings of this strikingly distinct variety.

Vaginulina bruckenthali has only been found living at a single locality,—off Raine Island, Torres Strait, 155 fathoms.

The fossil specimens which serve as the basis of the original description were obtained from the Miocene of Ober-Lapugy, in Transylvania.

Vaginulina linearis, Montagu, sp. (Pl. LXVII. figs. 10–12).

Nautilus linearis, Montagu, 1808, Test. Brit., Suppl., p. 87, pl. xxx. fig. 9.
Marginulina vaginella, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 152, pl. viii. fig. 2.
Vaginulina striata, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 182, pl. xvi. fig. 17.
Dentalina legumen, var. *linearis*, Williamson, 1858, Rec. For. Gt. Br., p. 22, pl. ii. figs. 46–48.
Vaginulina linearis, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 343, pl. xiii. figs. 12, 13.
„ *eocœna*, Gümbel, 1868, Abh. d. k. bayer. Akad. d. Wiss., II. Cl., vol. x. p. 632, pl. i. fig. 48, *a.b.*
Cristellaria dilute-striata, Id. Ibid., p. 639, pl. i. fig. 69.

Vaginulina linearis has the same morphological characters as the typical *Vaginulina legumen*, but the surface of the test is more or less decorated with raised longitudinal

costæ. The ribs seldom or never extend the entire length of the shell, but usually commence at the primordial end and run either parallel to the long axis, or more frequently in a somewhat oblique direction, as shown in Williamson's drawings, (*loc. cit.*, figs. 46, 47).

It would appear from the distribution-list that *Vaginulina linearis* is only really at home in comparatively shallow water on the Atlantic shores of Europe. The species has been obtained from three Challenger Stations, namely:—off Bermuda, 435 fathoms; off Culebra Island, 390 fathoms; and off the coast of South America, south-east of Pernambuco, 350 fathoms; but the specimens are few in number and hardly ever typical as to minor characters; whilst in some portions of the British seas, *e.g.*, Berwick Bay, Shetland, and the Hebrides, at depths of 15 to 90 fathoms it is one of the commoner Foraminifera. It occurs also on the western coast of Norway and of France.

In the fossil condition it has been found at least as far back as the London Clay; and specimens, identical in all important characters, are recorded from several microzoic formations of Middle and Later Tertiary age.

Vaginulina patens, n. sp. (Pl. LXVII. figs. 15, 16).

Test elongate, complanate, broadest near the middle, tapering to a point at the apertural end; aboral end broad or rounded, but finishing in a short stout spine. Dorsal edge thin, nearly straight, ventral margin thickest near the middle, square or somewhat bicarinate. Segments about twelve in number; long, narrow, slightly bent; obliquely set or nearly erect. Length, $\frac{1}{35}$th inch (0·74 mm.).

This is one of the complanate or Planularian forms of *Vaginulina*. The test bears a strong resemblance to that of *Planularia costata*, Cornuel (Mém. Soc. géol. France, sér. 2, vol. iii. Mém. III. p. 253, pl. ii. figs. 5–8), from which it differs chiefly in the absence of sutural limbation. The distinction is not one of much importance, and the recent specimens might without impropriety have been assigned to Cornuel's species, but that the term "*costata*," which refers to the raised sutural lines, is likely to lead to confusion as applied to a member of a genus, some of the varieties of which are costate in the ordinary sense, that is to say, have parallel longitudinal ribs. Moreover, the same specific name had previously been used by d'Orbigny in connection with the genus *Vaginulina*, though for what particular form does not appear.

The figured specimens are from the Philippine Islands, 95 fathoms, and two or three examples have been found off Raine Island, Torres Strait, 155 fathoms; but the species has not been met with elsewhere in the recent condition.

Cornuel's *Planularia costata* is one of the fossil species from the Lower Cretaceous beds of the Department of Haute-Marne in France.

Cristellaria, Lamarck.

Nautilus, pars, Plancus [1739], Linné, Soldani, Walker, Fichtel and Moll, Maton and Rackett, Montagu, Dillwyn, Sowerby, Turton, Fleming, Brown.
Lenticulites, pars, Lamarck [1804], Defrance, Blainville, Nilsson, Hisinger.
Linthuris, *Oreas*, Montfort [1808], Defrance, Blainville.
Phonemus, *Pharamum*, *Antenor*, *Robulus*, *Patrocles*, *Sphincterulus*, *Clisiphontes*, *Herion*, *Rhinocurus*, *Macrodites*, *Lampas*, *Scortimus*, *Astacolus*, *Periples*, Montfort [1808].
Cristellaria, Lamarck [1816], Defrance, d'Orbigny, Roemer, Philippi, Reuss, Czjzek, Cornuel, Bornemann, Costa, Egger, Williamson, Parker and Jones, Karrer, Carpenter, &c.
Lenticulina, pars, Lamarck [1822], Defrance, Blainville.
Polystomella, pars, Lamarck [1822], Blainville, Macgillivray, Thorpe.
Crepidulina, Defrance [1824], Blainville.
Saracenaria, Defrance [1824], Blainville, d'Orbigny.
Planularia, Defrance [1824], d'Orbigny, Münster, Roemer, Hagenow, Philippi, Karsten, Boll, Jones and Parker, Brady, Wright, Blake, Seguenza.
Robulina, d'Orbigny [1826], Roemer, Bronn, Michelotti, Reuss, Czjzek, Bailey, Bornemann, Abich, Costa, Egger, Terquem, &c.
Marginulina, pars, Sowerby [1834] Philippi, Cornuel, Jones, Bornemann, Parker and Jones, Brady, Gümbel.
Frondicularia, pars, Costa [1856].
Hemicristellaria, *Hemirobulina*, Stache [1864].

The essential features of the Cristellarian shell are the more or less planospiral arrangement of the segments and the terminal or periphero-terminal aperture. The test always exhibits a certain amount of lateral compression, but this character, as well as the extent to which the spiral mode of growth is maintained, varies in different species. In the more typical forms, such as *Cristellaria rotulata*, the shell is of lenticular contour, and spiral from beginning to end; in others, *Cristellaria crepidula* and *Cristellaria variabilis* for example, it is oval or oblong, and the later segments show a tendency to combine in a curved or oblique linear series; whilst in a few species, like *Cristellaria tenuis*, the helicoid segments are minute and inconspicuous, and the test is scarcely distinguishable from that of *Vaginulina*.

The convolutions of the shell are sometimes involute, that is to say, each whorl of chambers completely invests its predecessor, as in *Cristellaria rotulata;* sometimes evolute, with the whole of the segments visible on both lateral faces, as in *Cristellaria siddalliana;* and sometimes of intermediate character, showing a portion only of the earlier convolutions, near the centre on either side.

The form of the peripheral edge often furnishes the most salient morphological feature of the shell. In some members of the genus the margin is thick and rounded, in others it is angular and sharp, whilst in a certain number it spreads out so as to form a delicate lamelliform wing or keel, which is occasionally armed with radiating spines. In the partially uncoiled varieties, the ventral face or front aspect of the test also supplies distinctive characters of considerable importance, being sometimes very wide, as in

Cristellaria italica, and in other cases acutely angular or carinate, as in *Cristellaria variabilis*.

The aperture is either terminal and marginal, or situated in the peripheral angle of the final segment. It consists sometimes of a circular opening with the rim divided by radiating fissures; sometimes of a simple orifice, either round, oval, angular, or slit-like, with or without a radiate corona of embossed or depressed lines. D'Orbigny's division of the group into two genera, *Cristellaria* and *Robulina*, was based solely on the nature of the orifice, whether rounded or slit-shaped, a feature altogether too uncertain and variable to be of any service to the systematist.

The immediate allies of *Cristellaria* are *Vaginulina* and *Marginulina*. No hard lines of demarcation can be drawn between the three generic groups; but, broadly speaking, it may be said that *Cristellaria* differs from *Vaginulina* in the invariably spiral arrangement of the earlier chambers, and from *Marginulina* in its compressed contour—*Vaginulina* being typically entirely non-spiral, and *Marginulina* having rounded or subcylindrical segments.

The genus is distributed over an area stretching from the Arctic seas, lat. 79° 45′ N., to Magellans Strait, lat. 52° 50′ S. It inhabits all the great oceans, the Red Sea, the Mediterranean, and the Adriatic. Its bathymetrical range embraces every depth from the littoral zone to nearly 3000 fathoms, but it attains its best development on bottoms of from 50 to 500 fathoms.

The earliest appearance of fossil *Cristellariæ* is in the Upper Trias;[1] they are abundant in the Lias, and from that geological period down to Post-tertiary times they are met with in marine deposits of almost every age.

Cristellaria tenuis, Bornemann, sp. (Pl. LXVI. figs. 21–23).

Marginulina tenuis, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 326, pl. xiii. fig. 14.
Cristellaria perprocera, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 241, pl. vi. fig. 84.
,, *tenuis*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 479, No. 1.
,, *legumen*, Seguenza, 1880, Mem. R. Accad. dei Lincei, ser. 3, vol. vi. p. 141, pl. xiii. fig. 12.

This is one of the attenuated, linear group of *Cristellariæ*, the spiral segments of which are few and inconspicuous, and the normal contour of the shell compressed as in *Vaginulina*. Not unfrequently, however, the later segments are subcylindrical or inflated, like those of the Dentaline varieties of *Nodosaria*. The *Marginulina ensis* of Reuss (Haidinger's Naturw. Abhandl., vol. iv. p. 27, pl. ii. fig. 16), is a very similar form, but the test is subcylindrical throughout.

[1] Very recent observations place the first appearance of the genus as far back as the Lower Silurian. See footnote, p. 548.

Cristellaria tenuis occurs in sands dredged from five localities, namely :—the North Atlantic, off the south-west point of Ireland, 370 fathoms ; the South Atlantic, just south of the equator, 2350 fathoms ; off Raine Island, Torres Strait, 155 fathoms ; and two points off the west coast of New Zealand, 150 fathoms and 275 fathoms respectively.

It is difficult to lay down the geological distribution of this, as distinct from several closely-allied forms, but it is known at anyrate to occur in the Septaria-clay of Germany, as well as in some subsequent Tertiary deposits.

Cristellaria obtusata, Reuss (Pl. LXVI. fig. 17).

Cristellaria obtusata, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 479, No. 2 ;—Schlicht, 1870, Foram. Pietzpuhl, pl. xi. figs. 16–18.

I have accepted provisionally the name assigned by Prof. Reuss to a group of figures in von Schlicht's work, which represent better than many others the characters of certain recent specimens. I am nevertheless convinced that when the attenuated *Cristellariæ* of the Tertiary formations come to be critically studied as a whole, the number of species will be very greatly reduced, and probably this, amongst others, will be found needless.

The shells referred to were obtained from sands dredged off the Azores, 450 fathoms ; in the South Atlantic, 1990 fathoms ; off the Cape of Good Hope, 150 fathoms ; and off Raine Island, Torres Strait, 155 fathoms.

Von Schlicht's specimens were from the Septaria-clay of North Germany.

Cristellaria obtusata, var. *subalata*, nov. (Pl. LXVI. figs. 24, 25).

Test similar in contour and structure to that of *Cristellaria obtusata*, but furnished with a marginal wing or keel at the aboral end. Length, $\frac{1}{7}$th inch (3·6 mm.).

Under the name *Marginulina lituus*, d'Orb. (Phil. Trans., vol. clv., pl. xiii. fig. 14, *a.b.*), Parker and Jones figure a specimen somewhat more regular than those represented in Pl. LXVI. and with narrower keel, but presenting in other respects almost identical characters. The compressed Vaginuline form of the test, however, does not harmonise with the genus *Marginulina*, nor does the specimen answer well to the Soldanian figure of the species to which it is attributed. It appears to me in every way better to treat the form under consideration as a variety of *Cristellaria*, though of which particular species may be a matter of opinion.

Partially carinate specimens, such as those portrayed in the drawings, have been obtained at three or four points in the North Atlantic, at depths ranging from 130 to 630 fathoms.

Cristellaria wetherellii, Jones, sp. (Pl. CXIV. fig. 14).

Marginulina, sp., Sowerby, 1834, Trans. Geol. Soc. Lond., ser. 2, vol. v. p. 135, pl. ix. fig. 12.
,, *wetherellii*, Jones, 1854, Morris's Cat. Brit. Foss., p. 37.
,, ,, Parker and Jones, 1859, Ann. and Mag. Nat. Hist., ser. 3, vol. iv. p. 350.
,, *fragaria*, Gümbel, 1868, Abhandl. d. k. bayer. Akad. d. Wiss., II. Cl., vol. x. p. 635, pl. i. fig. 58, *a.b.c.*
Cristellaria asperula, Id. Ibid. pl. i. fig. 65, *a.b.*
,, *arcuata*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 51, pl. v. fig. 10.
,, *fragaria*, Id. Ibid. p. 53, pl. vi. figs. 1–3.

Amongst the numerous old friends that have turned up under new conditions during the investigation of the Challenger material, there are few that it has been a greater pleasure to meet with than this handsome and striking species, so familiar as a London Clay fossil.

The test of *Cristellaria wetherellii* is usually pod-like or crosier-shaped, but varies greatly in length and in the relative development of the spiral and linear portions. It is however always more or less spiral at the commencement, and almost invariably exhibits considerable lateral compression; therefore, so far as such characters are of any distinctive value, it belongs to the genus *Cristellaria* rather than to *Marginulina*. The salient feature of the species is its peculiar surface-decoration, consisting of closely-set raised tubercles, which take the place of continuous limbate septal lines. These are often, but not invariably, connected by slight, oblique, longitudinal costæ, most apparent on the earlier portions of the shell.

There are several figured varieties, besides those enumerated in the above synonymy, which cannot be separated from the present species by any valid zoological characters. Of these, *Cristellaria decorata*, Reuss (Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 269, pl. viii. fig. 16, pl. ix. figs. 1, 2), which differs in little beyond its slightly carinate margin; and *Marginulina hochstetteri*, Stache (Novara.–Exped., geol. Theil, vol. i., Paläont., p. 221, pl. xxii. fig. 55), which is represented by a nearly straight *Vaginulina*-like shell with the tubercles well developed but without costæ, are good examples, and there are many others which display similar surface-ornament but more nearly resemble the typical involute Cristellarians in their mode of growth.

Somewhat damaged recent specimens of *Cristellaria wetherellii* have been obtained at two Challenger Stations, namely:—off Raine Island, Torres Strait, 155 fathoms; and off the coast of South America, south-east of Pernambuco, 350 fathoms.

As a fossil the species dates back at least as far as the early part of the Tertiary epoch, if not to the Cretaceous formations. It is common in the London Clay (Jones and Parker, Brady), and occurs also in the Nummulitic Marl of the Bavarian Alps (Gümbel), in the *Clavulina-szabói* beds of Hungary (Hantken), and probably also in similar deposits of later geological age.

Cristellaria compressa, d'Orbigny (Pl. CXIV. figs. 15, 16).

Marginulina arcuata, (?) Philippi, 1843, Tert.-Verstein. nordwest. Deutsch., p. 5, pl. i. fig. 28.
Cristellaria compressa, d'Orbigny, 1846, For. Foss. Vien., p. 86, pl. iii. figs. 32, 33.
„ *arguta*, Reuss, 1855, Sitzungsb. d. k. Akad. Wiss. Wien, vol. xviii. p. 235, pl. iii. fig. 37.
„ *arcuata*, Id. Ibid. p. 233, pl. iii. figs. 34–36.
„ „ Id. 1864, Ibid. vol. l. p. 463, pl. ii. figs. 9–11.

Philippi, in his memoir on the Tertiary fossils of North-Western Germany, described and figured a considerable number of Foraminifera, chiefly *Nodosarinæ;* and his drawings, though too small and ill-defined to be of much value, derive a certain amount of importance from the attention bestowed upon them by subsequent writers. Amongst them are five figures of complanate Cristellarians, named respectively, "*Marginulina* (*Planularia?*) *spirata*, *Marginulina* (*Pl. ?*) *arcuata*, *Marginulina* (*Pl. ?*) *compressiuscula*, *Planularia intermedia*, and *Planularia semicircularis*," (*op. cit.*, pl. i. figs. 27, 28, 29, 38, 39), which were subsequently treated by Reuss as individual modifications of a single species, under the general name *Cristellaria arcuata*. It is to be regretted that out of the five specific names above quoted this in particular should have been selected, inasmuch as it had previously (in 1846) been employed by d'Orbigny for a different species of the same genus.

So far as the recent specimens are concerned, Philippi's figures are of little importance, and might have been passed over without remark, were it not that Reuss's illustrations of the same species embody the minor characters in which they were deficient, and are easily associated with the still living forms. Nevertheless, the d'Orbignian use of the specific term as applied to *Cristellaria* takes precedence, and the next available name for the variety under consideration appears to be *Cristellaria compressa*, from the "Vienna Basin" monograph.

The test of *Cristellaria compressa* is long, narrow, arcuate, and compressed or complanate; the peripheral edge is thin and partially carinate; the spiral commencement is evolute and distinct, and the later segments are long and obliquely set or nearly erect. The shell often attains a length of $\frac{1}{4}$th inch (6·3 mm.), or more.

Amongst the recent specimens are some (Pl. CXIV. fig. 15) which correspond pretty accurately with d'Orbigny's figure; whilst others (fig. 16) are relatively broader, and have a larger spiral commencement. From the latter it is easy to construct a gradational series uniting *Cristellaria compressa* with *Cristellaria reniformis*.

As a living organism the species is not uncommon in the North Atlantic, at depths ranging from 300 to 1000 fathoms, but has not been met with elsewhere.

In the fossil state it has been found in various Tertiary deposits of Germany, Austria, and Hungary.

Cristellaria reniformis, d'Orbigny (Pl. LXX. fig. 3, *a.b.*).

Cristellaria reniformis, d'Orbigny, 1846, For. Foss. Vien., p. 88, pl. iii. figs. 39, 40.

In typical examples of *Cristellaria reniformis* the test is somewhat more compressed than appears from the figure, and the earlier segments more distinctly evolute. The species is closely related to *Cristellaria compressa*, d'Orbigny, with which, as already stated, it is connected by passage-forms such as that represented in Pl. CXIV. fig. 16.

As a recent Foraminifer, *Cristellaria reniformis* is best known by North Atlantic specimens, from depths of 300 to 1000 fathoms, but it has also been found sparingly in the South Atlantic, 1900 fathoms; in the South Pacific, 150 fathoms to 1100 fathoms; and in the North Pacific, 2050 fathoms.

D'Orbigny's specimens were from the Miocene of Baden near Vienna.

Cristellaria schloenbachi, Reuss (Pl. LXVII. fig. 7).

Cristellaria schloenbachi, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 65, pl. vi. figs. 14, 15.

This is a mere variety—one of the numerous passage-forms between *Cristellaria crepidula* and the smooth *Vaginulinæ*.

It has been observed off Bermuda, 435 fathoms; off Culebra Island, 390 fathoms; and off Raine Island, 155 fathoms.

Reuss's specimens were obtained from various Upper Cretaceous deposits of North Germany.

Cristellaria lata, Cornuel, sp. (Pl. LXVII. fig. 18, *a.b*).

Marginulina lata, Cornuel, 1848, Mém. Soc. géol. France, sér. 2, vol. iii. p. 252, pl. i. figs. 34-37

Planularia pauperata, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 454, pl. xx. fig 39.

Cristellaria simplex, Terquem, 1863, Foram. du Lias, 3$^{i\ me}$ Mém., p. 203, pl. ix. fig. 15.

Planularia pauperata, Brady, 1867, Proc. Somerset. Arch. and Nat. Hist. Soc., vol. xiii. p. 110, pl. ii. figs. 24, 25.

Cristellaria pauperata, Blake, 1876, The Yorkshire Lias, p. 465, pl. xix. fig. 12.

A broad, few-chambered, complanate variety; only separable by comparative characters from *Cristellaria crepidula*.

Occurs off East Moncœur Island, Bass Strait, 38 fathoms.

The broad smooth Cristellarians, of which this is a subordinate modification, are better known as Mesozoic fossils (Trias, Lias, and Cretaceous), than in the living condition.

Cristellaria dentata, Karrer (Pl. CXIII. fig. 12, *a.b.*).

Cristellaria dentata, Karrer, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 348, pl. i. fig. 1.
„ *nummulitica*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 51, pl. vi. fig. 4, *a.b.*

There need be no hesitation, I think, in referring the figured specimen (Pl. CXIII. fig. 12) to this species, notwithstanding its somewhat stouter proportions and the nearly even outline of the carina. The irregularly dentate margin represented in Dr. Karrer's drawing is an accidental feature, not unfrequent amongst the carinate species of *Cristellaria* (see Pl. LXX. figs. 7, 8), and of little importance from a zoological point of view. The recent shell is more solidly built, and this is observable not only in the general conformation of the test but also in the greater thickness of the septa.

Morphologically speaking, *Cristellaria dentata* may be regarded as the typical or smooth form of *Cristellaria semiluna*, d'Orbigny (For. Foss. Vien., p. 90, pl. iii. figs. 43, 44) and only differs from that species by the absence of the costate surface-ornament. The figures referred by von Hantken (*loc. cit.*) to *Cristellaria nummulitica* have more in common with the present form than with the specimens figured by Gümbel under that name.

The single recent example of the species was taken off Kandavu, 210 fathoms, a locality wonderfully rich in *Cristellariæ*.

The fossil specimens obtained by Karrer and Hantken were from deposits of Middle Tertiary age in Austria and Hungary.

Cristellaria tricarinella, Reuss (Pl. LXVIII. figs. 3, 4).

Cristellaria tricarinella, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 68, pl. vii. fig. 9, and pl. xii. figs. 2–4.
„ *protosphæra*, Id. Ibid. p. 68, pl. vii. fig. 8; and pl. xii. fig. 10.
„ *truncana*, Gümbel, 1868, Abhandl. d. k. bayer. Akad. d. Wiss., II. Cl. vol. x. p. 639, pl. i. fig. 68, *a.b.*

This is a handsome, somewhat elongate species, thin and complanate, with nearly flat sides and limbate sutures, and sometimes showing a narrow but well-defined marginal keel. The peripheral margin is more or less limbate, as well as the septal lines, and the term "*tricarinella*" is not altogether inappropriate for carinate specimens.

The presence or absence of the marginal keel forms the chief distinction between Reuss's *Cristellaria tricarinella* and *Cristellaria protosphæra*, and the two specimens represented in Pl. LXVIII. figs. 3 and 4, would therefore be assigned one to each species were this accepted as a reliable character. But, judging by the recent examples, both the carina and the inflated primordial segment portrayed in some of the original figures are features far too uncertain and variable to have any really distinctive value.

Gümbel has pointed out (*loc. cit.*) the close resemblance of Reuss's species to the form described by himself under the name *Cristellaria truncana*; and I may add that after a careful comparison of the various figures with each other and with the recent specimens, I have been unable to recognise any character by which the two can be distinguished.

Cristellaria tricarinella has been collected at three localities, amongst the islands of the Western Pacific, as follows:—off the Philippine Islands, 95 fathoms; off Raine Island, Torres Strait, 155 fathoms; and off the west coast of New Zealand, 150 fathoms.

Reuss records the presence of the species as a Cretaceous fossil in the Hilsthon and Speeton-clay of North Germany; and Gümbel's specimens were from the Nummulitic Marl (Eocene) of the Götzreuther Graben, Kressenberg, Bavaria.

Cristellaria siddalliana, H. B. Brady (Pl. LXVIII. figs. 5–9).

Cristellaria siddalliana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 64.

Test spiral, explanate, with a tendency to become centrifugal or crosier-shaped; extremely thin; surrounded by a broad delicate wing, except the septal front of the terminal segment, or, in crosier-like specimens, the ventral margin of the projected chambers; the wing often extending between and separating the last two convolutions of the discoidal portion. Segments numerous, very slightly inflated, forming two to three convolutions, the whole of which are visible on both sides of the shell. Longer diameter, $\frac{1}{20}$th inch (1·26 mm.) or more.

This beautiful and very distinct species cannot be more fitly named than after a naturalist who has done so much good service to science as my friend Mr. J. D. Siddall of Chester.

It has only been found at a single locality,—off Kandavu, Fiji Islands, depth 210 fathoms.

Cristellaria variabilis, Reuss (Pl. LXVIII. figs. 11–16).

Cristellaria variabilis, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 369, pl. xlvi. figs. 15, 16.

„ *peregrina*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 245, pl. vii. fig. 89.

The drawings of this species (figs. 11–15) illustrate the curious mutations in form which take place during the growth of the test. Had space permitted, it would have been easy to introduce a more complete series, but these few figures are sufficient to indicate in a general way the successive stages through which the little orbicular organism (fig. 11) passes, before assuming the elongate and carinate aspect of the typical adult shell. They serve also to show the connection between two forms,

which at first sight appear very dissimilar—*Cristellaria variabilis* and *Cristellaria peregrina.*

Though it has not previously been recorded as a recent species, *Cristellaria variabilis* is by no means uncommon at depths ranging from 100 to 600 fathoms. It occurs at ten Stations in the North Atlantic, 50 fathoms to 1630 fathoms; at three in the South Atlantic, 350 fathoms to 675 fathoms; at seven in the South Pacific, 155 fathoms to 580 fathoms; and at one in the North Pacific, 345 fathoms.

Reuss's specimens were Miocene fossils from Baden, near Vienna, and from Felsö-Lapugy, in Transylvania; and those figured by Schwager were from the Upper Tertiary clay of Kar Nicobar.

Cristellaria crepidula, Fichtel and Moll, sp. (Pl. LXVII. figs. 17, 19, 20; Pl. LXVIII. figs. 1, 2).

Nautilus crepidula, Fichtel and Moll, 1803, Test. Micr., p. 107, pl. xix. figs. *g–i.*
Cristellaria crepidula, d'Orbigny, 1839, Foram. Cuba, p. 64, pl. viii. figs. 17, 18.
„ *berthelotiana*, Id. 1839, Foram. Canaries, p. 125, pl. i. figs. 14, 15.
„ *intermedia*, Reuss, 1845, Verstein. Böhm. Kreid., pt. i. pp. 33, 108, pl. xiii. figs. 57, 58;—pt. ii., pl. xxiv. figs. 50, 51.
„ *cymboides*, d'Orbigny, 1846, For. Foss. Vien., p. 85, pl. iii. figs. 30, 31.
„ *intermedia*, Alth., 1850, Haidinger's Naturw. Abhandl., vol. iii. p. 267, pl. xiii. fig. 23.
„ *jugleri*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 89, pl. iv. fig. 19, *a.b.*
„ *subarcuatula*, Williamson, 1858, Rec. For. Gt. Br., p. 29, pl. ii. figs. 56, 57.
„ *grata*, Reuss, 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 70, pl. vii. fig. 14.
„ *planiuscula*, Id. Ibid. p. 71, pl. vii. fig. 15.
„ *cordiformis*, Terquem, 1863, Foram. du Lias, 3ième mém. p. 203, pl. ix. fig. 14, *a.b.*
„ *acuminata*, Id. Ibid. p. 210, pl. x. fig. 5, *a.b.*
Hemirobulina compressa, Stache, 1864, Novara-Exped., geol. Theil, vol. i., Paläont., p. 229, pl. xxiii. fig. 8, *a.b.*
Cristellaria crepidula, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 344, pl. xiii. figs. 15, 16; pl. xvi. fig. 4.
„ *kochi*, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 139, pl. ii. fig. 35, *a.b.*
„ *galeata*, Id. Ibid. p. 141, pl. iii. fig. 8, *a.b.*

Fichtel and Moll's figures of *Nautilus crepidula* embody the typical characters of a large group of the weaker varieties of *Cristellaria* distinguished by their compressed form, elongate-oval outline, and long oblique segments. The term may properly be confined to forms which have a thin, rounded, non-carinate periphery, and smooth exterior.

An interesting example of this species, found by Mrs. Shone of Chester in the estuary of the Dee, is represented in Pl. LXVIII. figs. 1, 2. The shell-wall is thin, and the entire specimen is sufficiently transparent, mounted in Canada balsam, to be examined by transmitted light. In the interior of three of the chambers are seen a number of minute calcareous shells—young individuals in their earliest stage of development, or, more correctly, in their first calcareous investment. They have the appearance of rounded or subangular cells, either single or with a second, smaller cell adhering to the surface. The larger individuals closely resemble the primordial segment of the parent test. The viviparous mode of reproduction amongst the Foraminifera, of which this is an illustration, is no new fact, having been observed in *Spirillina* by Ehrenberg and Strethill Wright, and in *Rotalia* by Max Schultze, many years ago.

Cristellaria crepidula affects comparatively shallow water and temperate latitudes, and is not abundant either in the Challenger or the "Porcupine" dredged material. It is found as far north as the Hunde Islands, Davis Strait (lat. 68° 50′ N.), and is not uncommon at moderate depths on the shores of Norway, the British Islands, Belgium, and France; it also occurs in the Mediterranean, and in the Adriatic. Specimens have been taken in the North Atlantic, at depths of 300 to 450 fathoms; in the South Pacific, from 6 fathoms to 580 fathoms; and at a single point in the North Pacific, 40 fathoms. At one locality only has it been met with at a great depth, namely, Station 346, in the tropical part of the South Atlantic, 2350 fathoms.

Geologically speaking, the species dates back as far as the Lias, and its presence in the Chalk of Ireland, in the London Clay, and in various later Tertiary formations of Italy, Spain, and Austria is on record.

Cristellaria acutauricularis, Fichtel and Moll, sp. (Pl. CXIV. fig. 17, *a.b.*).

"Hammoniæ subrotundæ," &c., Soldani, 1879, Testaceographia, vol. i. pt. 1, p. 61, pl. xlix. fig. X.
Nautilus acutauricularis, Fichtel and Moll, 1803, Test. Micr., p. 102, pl. xviii. figs. *g–i.*
Cristellaria navicula, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. Mém. I. p. 27, pl. ii. figs. 19, 20.
,, *polita*, Reuss, 1855, Sitzungsb. d. k. Akad. Wiss. Wien, vol. xviii. p. 237, pl. iii. fig. 41.
Robulina limbata, pars, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 335, pl. xv. figs. 4, 5.
Cristellaria acutauricularis, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 114, No. 20.

This is a thick ovoid variety, with broad, nearly flat, septal face; a passage-form between *Cristellaria crepidula* or *Cristellaria gibba* on the one hand, and *Cristellaria arcuata* or *Cristellaria italica* on the other.

Cristellaria acutauricularis is not very common in the recent condition. Specimens

have been met with at three points in the North Atlantic, the depths varying from 390 to 2750 fathoms; off the Cape of Good Hope, 150 fathoms; at six Stations in the South Pacific, 155 to 2350 fathoms; and off the Philippine Islands, 95 fathoms. The Mediterranean is quoted as the habitat by Fichtel and Moll.

The geological range of the species extends at least as far back as the Chalk, probably to the Lias; and it has been found in many subsequent formations.

Cristellaria latifrons, n. sp. (Pl. LXVIII. fig. 19; Pl. CXIII. fig. 11, *a.b.*).

Test spiral, elongate, trihedral, broadest near the middle and tapering towards the ends; dorsal margin acutely angular and carinate; ventral face broad, oval, somewhat curved, and with partially carinate lateral edges; oral extremity pointed, aboral end thin and carinate. Early segments small and involute; later chambers long, narrow, slightly curved, obliquely set or almost erect. Length, $\frac{1}{18}$th inch (1·4 mm.).

This very striking and beautiful variety belongs to the same section of the genus as *Cristellaria arcuata*, d'Orbigny, and *Cristellaria acutauricularis* (F. and M.). It is distinguished by its broad front, its long, narrow, suberect chambers, and the more or less carinate development of the three salient angles of the test. These characters are best exemplified by the specimen figured in Pl. CXIII.

Cristellaria latifrons is exceedingly rare, and has only been met with off the west coast of New Zealand, 275 fathoms, and off Culebra Island, West Indies, 390 fathoms.

Cristellaria italica, Defrance, sp. (Pl. LXVIII. figs. 17, 18, 20–23).

Saracenaria italica, Defrance, 1824, Dict. Sci. Nat., vol. xxxii. p. 177;—vol. xlvii. p. 344.—Atlas Conch., pl. xiii. fig. 6.
„ „ Blainville, 1825, Man. de Malacol. p. 370, pl. v. fig. 6.
Cristellaria (*Saracenaria*) *italica*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 293, No. 26.—Modèles, Nos. 19 and 85.
Frondicularia triedra, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 174, pl. xiii. figs. 26, 27.
Cristellaria italica, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. pp. 21, 32, pl. i. figs. 41, 42.
„ (*Marginulina*) *italica*, var. *cincta*, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 383, pl. xvi. *b.* fig. 38.
„ „ „ var. *aureola*, Id. Ibid. p. 383, pl. xvi. *b.* fig. 39.

De Blainville's figure of *Saracenaria italica* represents an unusually short and broad example of the species, typical only in its distinctly trifacial contour. D'Orbigny's Model, No. 85, is based upon an adult shell of average proportions, and forms in every respect a more serviceable type. Model No. 19 purports to be taken from a young

individual of the same species, and this may be correct, but it differs considerably from any young specimens that have come under my notice.

The test of *Cristellaria italica* is elongate and trihedral; the planospiral segments are few and inconspicuous, whilst those of the body of the shell are superimposed so as to form a curved line. The convex or dorsal margin is sharp but not carinate, and the ventral face is so broad that the transverse section of the shell has the form of a nearly equilateral triangle. The segments are short and obliquely set, dipping at the front more or less towards the initial end, as in *Vaginulina*.

These characters in their fullest devolopment separate *Cristellaria italica* in a striking manner from the helicoid members of the genus, but the connection of the entire group is maintained by an unbroken chain of intermediate varieties. Amongst the numerous broad-fronted passage-forms leading to the present species are *Marginulina triangularis*, d'Orbigny (For. Foss. Vien., p. 71, pl. iii. figs. 22, 23), *Cristellaria arcuata* (Id. Ibid., p. 87, pl. iii. figs. 34–36), *Cristellaria vaginalis*, Reuss (Sitz. d. k. Ak. Wiss. Wien, vol. xlviii. p. 50, pl. iv. fig. 49), and *Cristellaria acutauricularis*, F. and M., sp. (Test. Micr., p. 102, fig. 18, figs. *g–i*).

Cristellaria italica has been taken at four Stations in the North Atlantic, at depths ranging from 390 fathoms to 725 fathoms, and at four in the South Pacific, 145 fathoms to 410 fathoms. In certain localities, notably off Culebra Island, West Indies, and off Kandavu, Fiji Islands, the specimens attain large dimensions, and are sometimes as much as $\frac{1}{5}$th inch (5 mm.) in length. It occurs also in the Mediterranean, 90 fathoms, and in the comparatively shallow water of the Adriatic. There is no record of its presence in the South Atlantic, the North Pacific, or the Southern Ocean.

The species has been found in the Cretaceous formations of the north of Ireland (Wright), in the London Clay (Parker and Jones), and in the later Tertiaries of Austria, Italy, and Spain (d'Orbigny, Parker and Jones, Seguenza).

Cristellaria italica, var. *volpicellii*, Costa (Pl. LXVII. fig. 9, *a.b.*).

Cristellaria volpicellii, Costa, 1855, Mem. Acad. Sci. Napoli, vol. ii. p. 120, pl. i. fig. 4, *a.b.*

The original drawing of *Cristellaria volpicellii* represents a short variety of *Cristellaria italica*, with carinate dorsal margin and thick, clear, septal lines. The specimen appears to have been somewhat more curved than the recent shell portrayed in Pl. LXVII., but the figures agree perfectly in other respects.

The only habitat at which this carinate variety has been observed is Station 335, South Atlantic, mid-ocean, depth 1425 fathoms.

The type specimens described by Costa were obtained from the Blue Vatican Marl of Rome.

Cristellaria convergens, Bornemann (Pl. LXIX. figs. 6, 7).

Cristellaria convergens, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 327, pl. xiii. figs. 16, 17.
„ *elliptica*, Id. Ibid. p. 328, pl. xiii. fig. 18.

The test of *Cristellaria convergens* is oval and biconvex, its peripheral edge is sharp but non-carinate, and the terminal segment is drawn out to a point at the apertural end. The species is distinguished from its congeners by the peculiar shape of the segments, the two outer lateral edges of which are drawn together so as to leave an extremely narrow septal face. The septation is very obscure, often scarcely visible externally, owing to the thickening of the walls by the extension of the alar flaps of the chambers over the sides of the shell. It is to the convergence of the edges of the final segment and the embracing nature of the chambers that the characteristic outline of the shell is due.

The best specimens of *Cristellaria convergens*, and those with thickest walls, have all been taken from very deep bottoms; and it is possible that the form may only represent a deep-water variety of *Cristellaria gibba*, or some such species, though it appears to have well differentiated characters in its fully developed condition.

This species has been found at four Stations in the North Atlantic, at depths ranging from 390 to 2740 fathoms; at one point in the South Atlantic, 2350 fathoms; at four in the South Pacific, 16 to 1375 fathoms; and at one in the North Pacific, 1850 fathoms.

The specimens originally described by Bornemann were Tertiary fossils, from the Septaria-clay of Hermsdorf near Berlin.

Cristellaria gibba, d'Orbigny (Pl. LXIX. figs. 8, 9).

Cristellaria gibba, d'Orbigny, 1839, Foram. Cuba, p. 63, pl. vii. figs. 20, 21.
„ *excisa*, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 328, pl. xiii. figs. 19, 20.
„ *nuda*, Reuss, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 328, pl. vi. figs. 1–3.
„ *pulchella*, Id., 1862, Ibid. vol. xlvi. p. 71, pl. viii. fig. 1.
Robulina concinna, Id., 1863, Ibid. vol. xlviii. p. 52, pl. v. fig. 58.

Cristellaria gibba occupies an intermediate position as one of the transition forms connecting the elongate compressed *Cristellaria crepidula* with the symmetrical and lenticular *Cristellaria rotulata*. The test is oblong and biconvex, and differs from that of *Cristellaria acutauricularis* chiefly in its comparatively narrow septal face.

These closely allied varieties of *Cristellaria* are so much associated in distribution that it is next to impossible to give an account of their individual geographical range. Notes have been preserved of the occurrence of *Cristellaria gibba* in the North Atlantic and the

South Pacific, at depths of less than 500 fathoms; but this is probably only a small portion of the area it inhabits.

A similar remark might be made with reference to its geological distribution. Under one name or other, the present variety has been recorded from microzoic rocks of almost every age as far back as the Cretaceous period.

Cristellaria articulata, Reuss (Pl. LXIX. figs. 10–12; wild-growing forms, figs. 1–4).

Robulina articulata, Reuss, 1863, Sitzungsb. d. k. Akad. Wiss. Wien, vol. xlviii. p. 53, pl. v. fig. 62,
Cristellaria articulata, Id., 1870, Ibid. vol. lxii. p. 483.—Schlicht, 1870, Foram. Pietzpuhl, pl. xvii. figs. 5–12.

This is a thick variety of *Cristellaria rotulata*, with somewhat flattened sides and obtusely angular or rounded peripheral edge. The segments are relatively large, and seldom number more than six or seven in the final convolution. In some specimens the later chambers only partially enclose those of the previous convolution, and the test shows a tendency to become evolute. There is frequently considerable deposit of clear shell, substance, especially in the umbilical region.

Fine examples of *Cristellaria articulata* occur in the dredged sands from off Culebra Island, 390 fathoms; and off Nightingale Island, Tristan da Cunha, 100 to 150 fathoms. In the latter locality the species is very abundant, and what is more remarkable, a large proportion of the shells assume anomalous wild-growing forms, such as are represented in figs. 1–4. Strikingly different as they appear, the relationship between these and the more regular and typical specimens is very evident when a large number are seen together.

The fossil examples of the species figured by v. Reuss and v. Schlicht were from the Septaria-clays of Offenbach and Pietzpuhl in Germany.

Cristellaria rotulata, Lamarck, sp. (Pl. LXIX. fig. 13, *a.b.*).

"Cornu Hammonis seu Nautili," Plancus, 1739, Conch. Min., p. 13, pl. i. fig. III.
Lenticulites rotulata, Lamarck, 1804, Annales du Muséum, vol. v. p. 188, No. 3.—Tableau Encycl. et Méth., pl. cccclxvi. fig. 5.
Robulina muensteri, Roemer, 1841, Verstein. norddeutsch. Kreid., pt. 2, p. 98, pl. xv. fig. 30.
,, *simplex*, d'Orbigny, 1846, For. Foss. Vien., p. 102, pl. iv. figs. 27, 28.
,, *stellifera*, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 142, pl. xii. figs. 26, 27.
,, *trigonostoma*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 69, pl. iv. fig. 26.
,, *neglecta*, Id. Ibid. p. 69, pl. iv. fig. 27.
,, *deformis*, pars, Bornemann, 1855, Ibid. vol. vii. p. 337, pl. xiv. fig. 1.
,, *depauperata*, Id. Ibid. p. 337, pl. xiv. fig. 11.
,, *incompta*, (?) Id. Ibid. p. 336, pl. xiv. fig. 12.
Cristellaria calcar (typica), Williamson, 1858, Rec. For. Gt. Br., p. 27, pl. ii. figs. 52, 53.
,, *rotulata*, Parker and Jones, 1865, Phil. Trans., vol clv. p. 345, pl. xiii. fig. 19.
,, *inornata*, Terquem, 1876, Anim. sur la Plage de Dunkerque, p. 70, pl. vii. fig. 18
,, *austriaca*, Id. Ibid. p. 70, pl. vii. fig. 20, *a.b.*

Cristellaria simplex, Terquem, 1876, Anim. sur la Plage de Dunkerque, p. 70, pl. vii. fig. 21, *a.b.*
Robulina simplicissima, Seguenza, 1879, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 141, pl. xiii. fig. 18.
,, *lucida*, Id. Ibid. p. 142, pl. xiii. fig. 19.
Cristellaria falcifer, Stache, 1864, Novara-Exped., geol. Theil, vol. i. Paläont., p. 240, pl. xxiii. fig. 19, *a.b.*

Cristellaria rotulata takes precedence as the type of the simplest forms of the lenticular and involute Cristellarians. The test is biconvex, has a sharp peripheral edge but no marginal keel, and is smooth externally.

This species is one of the most widely diffused of all Foraminifera. In the living condition it is found far within the Arctic Circle (to lat. 79° 45′ N.), and as far south as Tierra del Fuego. It occurs in the North Atlantic at every depth from the littoral zone down to 1630 fathoms; in the South Atlantic down to 2200 fathoms; in the South Pacific down to 2075 fathoms; in the North Pacific to 345 fathoms; and in the Mediterranean to 1200 fathoms; as well as in the shallow waters of the Adriatic.

As a fossil *Cristellaria rotulata* has been observed in the Upper Trias of Derbyshire[1] (Jones and Parker); in the Lower, Middle, and Upper Lias of England (Brady, Blake); in the Cretaceous formations of England, Ireland, Germany, and elsewhere (Sowerby, Jones, Wright, &c.); and in almost every marine microzoic deposit of the Tertiary epoch, from the Eocene beds of the London Basin to the Glacial Clays of Norway and Scotland.

Cristellaria vortex, Fichtel and Moll, sp. (Pl. LXIX. figs. 14–16).

"Nautili *globuli*," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 66, pl. lix. fig. *tt.*
Nautilus vortex, Fichtel and Moll, 1803, Test. Micr., p. 33, pl. ii. figs. *d–i.*
Polystomella vortex, Blainville, 1825, Man. de Malacol., p. 389.
Robulina vortex, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 288, No. 4.
Cristellaria vortex, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 240, pl. x. fig. 82.
Robulina serpens, Seguenza, 1879, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 143, pl. xiii. fig. 25.

The specific term "*vortex*" has reference to the sweeping curves of the long narrow chambers, terminating in the central umbo. This peculiarity of form and mode of combination constitutes the most distinctive feature of the shell.

Small starved specimens of *Cristellaria vortex* have been met with in sands dredged on the west coast of Scotland. It occurs at one Challenger Station in the North Atlantic —off Bermuda, 435 fathoms; and at four in the South Pacific—off Kandavu, Fiji, 210 fathoms; off Tahiti, 420 fathoms; off New Hebrides, 125 fathoms; and off Raine Island, Torres Strait, 155 fathoms. Parker and Jones record its presence at three points in the Mediterranean, at depths between 90 and 360 fathoms.

[1] Since the revision of these proof-sheets my attention has been called by my friend Professor Rupert Jones to the figure of a specimen obtained from the Lower Silurian strata of Cincinnati, which to all appearance is correctly assigned to the present species. *Vide*,—"*Cristellaria rotulata*? d'Orb."—Ulrich, 1882 (?), *Journ. Cincin. Soc. Nat. Hist.*, vol. v. p. 119, pl. v. figs. 2, 2*a*.

In the fossil state it occurs in the Septaria-clays of North Germany (Reuss), in the Schlier of Lower Austria (Karrer), in the Subapennine Tertiaries of Italy, and in clays of similar age near Malaga (Soldani, Parker and Jones, &c.).

Cristellaria orbicularis, d'Orbigny, sp. (Pl. LXIX. fig. 17).

'Nuclei *conico rotundati*," Soldani, 1798, Testaceographia, vol. ii. App. p. 138, pl. i. fig. 12, *p. P.*
Robulina orbicularis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 288, pl. xv. figs. 8, 9.
,, *imperatoria*, Id. 1846, For. Foss. Vien., p. 104, pl. v. figs. 5, 6.

The chambers of *Cristellaria orbicularis* present the same general form and disposition as those of *Cristellaria vortex*, but the periphery of the test is extended so as to form a well-defined wing or keel. The two species in fact bear just the same relation to each other as *Cristellaria rotulata* and *Cristellaria cultrata*.

The carinate form has been found at one Station in the North Atlantic, off Sombrero Island, West Indies, 450 fathoms; and at five in the South Pacific, namely—off Kandavu, 210 fathoms; off Tahiti, 420 fathoms; off the west coast of New Zealand, 150 fathoms; off Sydney, New South Wales, 410 fathoms; and off East Moncœur Island, Bass Strait, 38 fathoms.

As a fossil it occurs in the Subapennine formations of Central Italy, and in the Miocene of the Vienna Basin.

Cristellaria crassa, d'Orbigny (Pl. LXX. fig. 1, *a.b*).

Cristellaria crassa, d'Orbigny, 1846, For. Foss. Vien., p. 90, pl. iv. figs. 1–3.
Robulina deformis, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesell., vol. iii. p. 70, pl. iv. fig. 30.

This is a biconvex variety, very thick in proportion to its diameter, having only about three chambers visible externally, and furnished with a narrow marginal keel.

Cristellaria crassa has been found living amongst allied forms, off Kandavu, 210 fathoms, but not elsewhere.

The locality given by d'Orbigny for his fossil specimens is the Miocene of Baden near Vienna; that given by Reuss, the Septaria-clay of Hermsdorf near Berlin.

Cristellaria nitida, d'Orbigny (Pl. LXX. fig. 2, *a.b*).

"Nautili *Lituitati*," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 64, pl. lvi. figs. O. P.
Cristellaria nitida, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 291, No. 5.
Cristellaria cassis (pars), Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 244, pl. x. fig. 88.

A feeble modification belonging to the "*cassis*" and "*mamilligera*" group. The shell is compressed and carinate and the earlier sutures limbate. It is a doubtful and unsatisfactory species.

The recent specimens are from off the Philippines, 95 fathoms.

Those figured by Soldani were fossils found in the Subapennine beds of Sienna; d'Orbigny's, from the same formation, near Coroncina.

Cristellaria cultrata, Montfort, sp. (Pl. LXX. figs. 4, 5, 6; dentate variety, figs. 7, 8).

"Cornu Hammonis," Plancus, 1760, Conch. Min., ed. altera, p. 120, pl. i. fig. XII., see p. 552.
"Nautili (*Lenticulæ marginatæ*)," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 54, pl. xxxiii. figs. B, &c.
Robulus cultratus, Montfort, 1808, Conchyl. Systém., vol. i. p. 214, 54e genre.
Robulina cultrata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 287, No. 1.—Modèle No. 82.
„ *canariensis*, Id. 1839, Foram. Canaries, p. 127, pl. iii. figs. 3, 4.
„ *subcultrata*, Id. 1839, Foram. Amér. Mérid., p. 26, pl. v. figs. 19–20.
„ *cultrata*, Id. 1846, For. Foss. Vien., p. 96, pl. iv. figs. 10–13.
„ *similis*, Id. Ibid. p. 98, pl. iv. figs. 14, 15.
Cristellaria hoffmanni, Ehrenberg, 1854, Mikrogeologie, pl. xxvi. fig. 53.
Robulina limbosa, Reuss, 1863, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlviii. p. 55, pl. vi. fig. 69.
Cristellaria gyroscalprum, Stache, 1864, Novara-Exped., geol. Theil, vol. i. Paläont., p. 243, pl. xxiii. fig. 22, *a.b.*
Robulina cultrata, var. *antipodum*, Id. Ibid. p. 251, pl. xxiii. fig. 30, *a.b.*
„ *tœttovata*, Id. Ibid. p. 253, pl. xxiii. fig. 32, *a.b.*
Cristellaria cultrata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 344, pl. xiii. figs. 17, 18; pl. xvi. fig. 5.
Robulina curvispira, Seguenza, 1879, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 144, pl. xiii. fig. 28.
„ *stellata*, Id. Ibid. p. 144, pl. xiii. fig. 29.
„ *dubia*, Id. Ibid. p. 144, pl. xiii. fig. 30.

The conspicuous feature of *Cristellaria cultrata* is the well-marked wing or keel surrounding the body of the test. The general contour of the shell is discoidal and biconvex, and the exterior is smooth and devoid of ornament. Briefly, its morphological characters are those of *Cristellaria rotulata*, with the addition of the marginal keel.

The width of the laminar extension of the periphery varies with each individual specimen; in some it occupies as much as one-third of the entire diameter of the test. whilst in others it is no more than a very narrow rim or border. Its outer margin is usually even and unbroken, but occasionally it is more or less serrate, as shown in figs. 7 and 8.

The geographical distribution of *Cristellaria cultrata* is similar to that of the closely allied *Cristellaria rotulata*, but the area is scarcely so extensive. It has been found as far north as the Arctic Circle on the coast of Norway, and as far south as lat. 50° S. on the shores of Patagonia. As a rule it affects deeper water than the non-carinate form, and fine specimens are rarely met with at less than 100 fathoms. The distribution-list comprises twelve Stations in the North Atlantic, at depths from 390 to 2435 fathoms; two in the South Atlantic, 350 fathoms and 675 fathoms respectively; seven in the South Pacific, 38 to 275 fathoms; one in the North Pacific, 95 fathoms; and

others in the Mediterranean, Adriatic, and elsewhere. Small specimens, with very narrow keel, have occasionally been dredged in shallow water in the British seas.

The earliest known fossil specimens are those from the Lias. The species occurs in Tertiary deposits of almost every geological age.

Cristellaria calcar, Linné, sp. (Pl. LXX. figs. 9–15).

"Nautilus minimus non umbilicatus," Gaultieri, 1742, Index Test., pl. xix. fig. C.

"Nautili (*Lenticulæ radiatæ*)," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 54, pl. xxxiii. figs. *aa*, *bb*.—"Nautili carinati (*Lenticulæ*)," Ibid., p. 64, pl. lxviii. figs. *hh*, *mm*.

Nautilus calcar, Linné, 1767, Syst. Nat., 12th ed., p. 1162, No. 272;—1788, Ibid., 13th (Gmelin's) ed., p. 3370, No. 2.

„ „ var. α, ε, δ, κ, μ, Fichtel and Moll, 1803, Test. Micr., p. 69, pl. xi. figs. *a.b.*; pl. xii. figs. *a.b.c.*; *i.k.*, pl. xiii. figs. *c.d.*; *h.i.*

Antenor diaphaneus, Montfort, 1808, Conchyl. Syst., vol. i. p. 71, genre 18°.

Clisiphontes calcar, Id. Ibid. p. 227, genre 57°.

Herion rostratus, Id. Ibid. p. 231, genre 58°.

Rhinocurus araneosus, Id. Ibid. p. 235, genre 59°.

Lenticulina diaphanea, Blainville, 1825, Man. de Malacol., p. 390.

„ *araneosa*, Id. Ibid. p. 390.

„ *calcar*, Id. Ibid. p. 390.

„ *rostrata*, Id. Ibid. p. 390.

Robulina aculeata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 289, No. 14.

„ *radiata*, Id. Ibid. p. 288, No. 7.

„ *pulchella*, Id. Ibid. p. 288, No. 8.

„ *calcar*, Id. 1846, For. Foss. Vien., p. 99, pl. iv. figs. 18–20.

Cristellaria calcar, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. pp. 241, 242, pl. x. figs. 91, 93, 94.

The name *Nautilus calcar* was assigned by Linné to the entire group of helicoid *Cristellariæ*, and, as might be expected, the illustrations of the species selected by him from the works of earlier writers, include a number of forms now regarded as varietally if not specifically distinct. The drawings referred to all represent *Cristellariæ* of the involute type, but they differ from each other in general conformation, as well as in details of structure. In some, the test is compressed and the peripheral edge is thick and rounded; in others, the general form is lenticular and the margin angular and sharp; whilst the remainder are characterised by a thin carinate periphery armed with short radiating spines.[1]

[1] The figures referred to in the 13th (Gmelin's) edition of the "Systema Naturæ," vol. i., part 6, p. 3370, are as follows :—

Plancus, *Conch. Min.*, pl. i. figs. 3, 4.
Gaultieri, *Index Test. Conch.*, pl. xix. figs. B. C.
Ledermüller, *Amus. Micros.*, pl. viii. figs. *c.d.*
Martini, *Conchyl. Cabinet*, pl. xix. figs. 168, 169;—

and of these Ledermüller's are copied from Plancus, and Martini's from Gaultieri.

Only two out of the eight figures above enumerated represent calcarate shells; therefore Williamson's use of the term "*Cristellaria calcar, typica*" (Rec. For. Gt. Br., p. 27, pl. ii. figs. 52, 53), for a non-spinous and non-carinate form, would have been quite in order, had not the name been employed in the interim by other authors in its present restricted sense.

Fichtel and Moll employ the Linnæan name for a somewhat less extensive morphological series, and illustrate the species by drawings of twelve varieties, including only those forms which have acute, carinate, or rowelled margins, the round-edged modifications being otherwise provided for.

It is evident that the specific term "*calcar*" was intended to refer to the spinous periphery; and in distinguishing by name the different varieties originally allotted to the specific group, the most natural course is to restrict its application to the most typical of the carinate and rowelled forms. This view has been adopted by d'Orbigny and many subsequent writers.

With this limitation, the shell of the typical *Cristellaria calcar* may be characterised as biconvex or lenticular in form, more or less carinate, and armed with a number of radiating peripheral teeth or spines. The sutures are sometimes slightly limbate, but otherwise the exterior is smooth and destitute of ornament. The width of the keel and the length of the spines vary in different specimens, as may be seen by the figures.

Good specimens of *Cristellaria calcar* have been found at three Stations in the North Atlantic—off Sombrero Island, West Indies, 450 fathoms, off Culebra Island, West Indies, 390 fathoms, and off the Azores, 450 fathoms; at five localities amongst the islands of the South Pacific, depth from 129 fathoms to 580 fathoms; and at one in the North Pacific, off the Philippines, 95 fathoms. The species occurs also in the Mediterranean and the Adriatic.

In the fossil condition it appears in various formations of middle and later Tertiary age in Germany, Austria, Italy, Spain, and elsewhere.

Cristellaria cassis, Fichtel and Moll, sp. (Pl. LXVIII. fig. 10).

"Cornu Hammonis," Plancus, 1760, Conch. Min., ed. altera, p. 120, pl. i. fig. xi.
"Litui *crispati* et *orbiculi*," Soldani, 1789, Testaceographia, vol. i., pt. 1, p. 63, pl. lvi. figs. I.K., &c.
Nautilus cassis, Fichtel and Moll, 1803, Test. Micr., p. 95, pl. xvii.
Linthuris cassidatus, Montfort, 1808, Conch. Syst., vol. i. p. 254, 64e genre.
Cristellaria cassis, Lamarck, 1816, Tabl. Encycl. et Méthod., pl. cccclxvii. fig. 3, *a–d.*
„ *producta*, Id. Ibid. pl. cccclxvii. fig. 3, *e–g.*
„ *serrata*, Id. Ibid. pl. cccclxvii. fig. 4, *a, b.*
„ *papilionacea*, Id. Ibid. pl. cccclxvii. fig. 4, *c, d.*
„ *undata*, Id. Ibid. pl. cccclxvii. fig. 5, *a–c.*
„ *papillosa*, Id. 1822, Anim. s. Vert., vol. vii. p. 607, No. 2.
„ *lævis*, Id. Ibid. p. 608, No. 3.
Linthuris cassis, Blainville, 1825, Man. de Malacol., p. 384, pl. x. fig. 3.
Cristellaria cassis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 290, No. 3.—Modèle, No. 44.
„ „ Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 244, pl. x. figs. 86, 87.

Nautilus cassis, as depicted by Fichtel and Moll, is a thin compressed Cristellarian, with somewhat narrow chambers and a wide peripheral keel. Of the four individuals

selected by the authors to illustrate its varietal modifications, three are more or less ornamented externally with raised beads or tubercles, either set irregularly near the umbilicus, or arranged along the sutural lines. Many of the subsequent drawings of the species, though similar in other respects to the figures referred to, are taken from biconvex, and relatively much thicker specimens.

Cristellaria cassis occurs in the rich coral-sand dredged off Kandavu, Fiji Islands, 210 fathoms. It is common in the Adriatic (Plancus, Michelotti, &c.), and has been obtained from the Mediterranean, off Syra, 90 fathoms (Parker and Jones).

As a fossil it dates back nearly to the commencement of the Tertiary epoch. It is found in the London Clay (Parker and Jones), in the Miocene of the Vienna Basin (d'Orbigny, Karrer), and of the Banat (Karrer); in the later Tertiaries of Italy (d'Orbigny, Seguenza, &c.), and of the neighbourhood of Malaga (Parker and Jones).

Cristellaria mamilligera, Karrer (Pl. LXX. figs. 17, 18).

Cristellaria mamilligera, Karrer, 1864, Novara-Exped., geol. Theil, vol. i., Paläont., Abth. ii. p. 76, pl. xvi. fig. 5.
Robulina gutticossata, Gümbel, 1868, Abhandl. d. k. bayer. Akad. d. Wiss., II. Cl., vol. x. p. 643, pl. i. fig. 74.

This is nothing more than a biconvex variety of *Cristellaria cassis*, and it is open to question whether any good end is served by admitting it to an independent position. Fichtel and Moll's figures of the typical form represent a thin flat shell, whilst the present variety is characterised by its stout lenticular contour, the carina and surface-ornament being the same in both cases.

The recent specimens were dredged off Kandavu, 210 fathoms, and off the Philippine Islands, 95 fathoms.

The fossil examples described by Karrer were from the Tertiary green sandstones of Orakei Bay, New Zealand; and those figured by Gümbel, from the Nummulitic Marl of Hammer (Kressenberg) in the Bavarian Alps.

Cristellaria papillosa, Fichtel and Moll, sp. (Pl. LXX. fig. 16).

Nautilus papillosus, Fichtel and Moll, 1803, Test. Micr., p. 82, pl. xiv. figs. *a.b.c.*
Cristellaria papillosa, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 113, No. 17.

Cristellaria papillosa differs from *Cristellaria cassis* in its thick biconvex contour, and the absence of the broad peripheral wing or keel. The surface of the shell is ornamented with raised tubercles, which generally follow the course of the septal lines. Parker and Jones treat this as an independent variety, and with some reservation I have adopted their view.

Examples of *Cristellaria papillosa* have been obtained from two localities,—off Kandavu, 210 fathoms; and off Culebra Island, West Indies, 390 fathoms. Fichtel and Moll mention the Adriatic as the habitat of their specimens.

Cristellaria echinata, d'Orbigny, sp. (Pl. LXXI. figs. 1–3).

"Nautili *Echinati*, sive *Papillosi*, & *Circumradiati*," Soldani, 1780, Saggio Oritt., p. 98, pl. i. fig. 6.—1789, Testaceographia, vol. i., pt. 1, p. 65, pl. lix. figs. *qq*, *rr*.
Nautilus calcar, var. ϵ, Fichtel and Moll, 1803, Test. Micr., p. 74, pl. xii. figs. *a.b.c.*
Robulina echinata, d'Orbigny, 1846, For. Foss. Vien, p. 100, pl. iv. figs. 21, 22.
„ „ Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 141, pl. xii. figs. 24, 25.

D'Orbigny describes, under the name *Robulina echinata*, a Cristellarian shell, with marginal keel and radiating rowel-like spines; the sutures are limbate, and the surface of the test is studded with raised beads or tubercles, which on the later chambers give place to partial costæ.

In the specimen figured by Czjzek, with the same appellation, the sutural limbation is to some extent broken up into tubercles, and the costate ornament is much more strongly developed; the shell in fact partakes almost equally of the characters of *Cristellaria echinata*, *Cristellaria calcar*, and *Cristellaria costata*.

Cristellaria echinata occurs at two points in the Western Pacific,—off the Philippine Islands, 95 fathoms; and off Kandavu, 210 fathoms. It was found by d'Orbigny in sands from the Adriatic.

The fossil specimens above referred to were from the Miocene of Baden, near Vienna, and the Tertiary deposits of Coroncina in Italy.

Cristellaria gemmata, H. B. Brady (Pl. LXXI. fig. 6, 7).

Cristellaria gemmata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 64.

Test planospiral, broad, oblong, compressed or complanate; lateral faces only slightly convex, dorsal edge acute or subcarinate; segments broad and arcuate, two or three of later ones free at both lateral margins; exterior ornamented with exogenous beads, arranged either upon the sutural lines, or, less frequently, in rows parallel to them. Length, $\frac{1}{20}$th inch (1·26 mm.).

This is one of the complanate or Planularian group of *Cristellariæ*. The dorsal edge of the test is sharp or subcarinate, and the septal face of the later segments, which forms the principal part of the ventral margin, is square. The sutural ornament resembles that of many specimens of *Cristellaria wetherellii* (without longitudinal costæ), and the surface of the chambers is sometimes rough, owing to the presence of minute tubercles or prickles.

Cristellaria gemmata has been observed in sands dredged at three Pacific Stations, namely:—off Kandavu, Fiji Islands, 210 fathoms; off Raine Island, Torres Strait, 155 fathoms; and off the Philippines, 95 fathoms.

Cristellaria aculeata, d'Orbigny (Pl. LXXI. figs. 4, 5).

"*Lituus innominatus*," Soldani, 1789, Testaceographia, vol. i., pt. 1, p. 64, pl. lvii. figs. T. *t.*
Cristellaria aculeata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 292, No. 14.
„ „ Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 303, No. 43.

The figure in the Testaceographia to which d'Orbigny assigned the name *Cristellaria aculeata*, is wanting in those details which under ordinary circumstances are necessary for the identification of a species. It is, however, quite evident that it is intended to represent a Cristellarian shell, the surface of which is beset with small spines, and the peripheral edge with a certain number of larger ones; indeed, there can be little doubt that the specimen from which the drawing was made was very similar to those of which figures are given herewith. The sutural lines are not represented in Soldani's illustration, but in the recent specimens they are marked by rows of rounded beads or tubercles.

Cristellaria aculeata has only been obtained in the living condition from two neighbouring Stations in the Danish West Indies:—off Culebra Island, 390 fathoms, and off Sombrero Island, 450 fathoms.

The habitat given by Soldani is the Subapennine formation of the vicinity of Sienna, to which d'Orbigny adds that of Coroncina. Parker and Jones report its occurrence in a Tertiary clay from near Malaga.

Cristellaria costata, Fichtel and Moll, sp. (Pl. LXXI. figs. 8, 9).

Nautilus costatus, Fichtel and Moll, 1803, Test. Micr., p. 47, pl. iv. figs. *g.h.i.*
Spincterules costatus, Montfort, 1808, Conchyl. Systém., p. 222, genre 56[e].
Lenticulina costata, Defrance, 1824, Dict. Sci. Nat., vol. xxxii. p. 182.—Blainville, 1825, Man. de Malacol., p. 390.
Robulina costata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 289, No. 13.
„ *ariminensis*, d'Orbigny, 1846, For. Foss. Vien., p. 95, pl. iv. figs. 8, 9.
Cristellaria costata, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 113, No. 19.

This is a handsome and interesting species, readily distinguished by its surface-ornament of stout concentric costæ, but liable to considerable variation as to its minor characters. Fichtel and Moll's original drawings represent a shell with limbate sutures in addition to the costæ, exactly as shown in fig. 9, but the periphery is more or less carinate. A thicker non-carinate specimen, of which the septa are scarcely visible

externally, is portrayed in fig. 8. D'Orbigny's figure (*Robulina ariminensis*) (*loc. cit.*) is taken from a comparatively thin shell, resembling Fichtel and Moll's in having a carinate margin, and with the same sort of concentric ornament, but the sutures are depressed. All these appear to be individual modifications of the same specific form.

Cristellaria costata has been taken at three Challenger Stations :—off Gomera, Canaries, 620 fathoms; off Kandavu, Fiji, 210 fathoms; and off Raine Island, Torres Strait, 155 fathoms. It is also reported from the shores of the Adriatic at Rimini and Lido.

In the fossil condition it has been found in the later Tertiary clays of the neighbourhood of Malaga (Parker and Jones); and if *Robulina ariminensis* be correctly assigned to the species, in the Miocene of the Vienna Basin (d'Orbigny).

Amphicoryne, Schlumberger.

Marginulina, pars, Jones and Parker [1860].
Amphicoryne, Schlumberger [1881].

The term *Amphicoryne* has been proposed by Schlumberger (Comptes Rendus, Nov. 28th, 1881, p. 881) for a small group of dimorphous Foraminifera, of which the earlier segments are arranged after the manner of *Cristellaria* and the later ones in a straight line, like those of *Nodosaria*. In the majority of cases, specimens answering to this description are obviously nothing more than monstrosities, as for example that represented by Pl. CXIII. fig. 13; but there are some varieties, notably the *Marginulina falx* of Jones and Parker, that present tolerably constant characters, and if dimorphous structure is to be admitted as a basis of subdivision amongst the *Nodosarinæ*, there is no reason why this should not rank with *Flabellina*, *Amphimorphina*, and the rest, under a distinctive name.

Amphicoryne falx, Jones and Parker, sp. (Pl. LXV. figs. 7–9).

Marginulina falx, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 302, No. 28.

Messrs. Jones and Parker (*loc. cit.*) describe this species in the following terms:—"An elegant dimorphous, striated, little *Nodosarina*, with the first six or seven cells arranged in the form of a partially uncoiled trihedral *Cristellaria* (or *Saracenaria* of Defrance), and with the last two, three, or four chambers rectilinear and not distinguishable from those of *Nodosaria longicauda*,[1] with which this variety is always associated in nature. *Nodosaria longicauda* may be regarded as the normal form to which this variety belongs."

Amphicoryne falx is not uncommon in the Mediterranean, at depths of less than 400 fathoms; it occurs also off the Cape of Good Hope, 150 fathoms; on the western shores of New Zealand, 275 fathoms; and off Raine Island, Torres Strait, 155 fathoms.

[1] *Nodosaria longicauda*, d'Orb, is now better known under its earlier name, *Nodosaria scalaris*, Batsch, sp.

Sub-family 3. Polymorphininæ.

Polymorphina, d'Orbigny.

Polymorphium, Soldani [1781].
Serpula, Walker [1784], Kanmacher.
Vermiculum, Montagu [1803], Fleming, Macgillivray.
Arethusa, Montfort [1808], Bowditch, Fleming, Thorpe.
Misilus, *Cantharus*, Montfort [1808].
Polymorphina, d'Orbigny [1826], Ehrenberg, Roemer, Macgillivray, Philippi, Reuss, Parker and Jones, Egger, Williamson, Terquem, Karrer, Carpenter, Gümbel, &c.
Globulina, d'Orbigny [1826], Sander Rang, Roemer, Reuss, Alth, Bornemann, Costa, Egger, Karrer, Schwager, Schlicht, Kübler, &c.
Guttulina, d'Orbigny [1826], Sander Rang, Roemer, Reuss, Alth, Bornemann, Costa, Egger, Karrer, Stache, Schlicht, Terquem, &c.
Pyrulina, d'Orbigny [1826], Sander Rang, Reuss, Morris and Jones, Ehrenberg, Schlicht.
Renoidea, pars, Brown [1827].
Raphanulina, pars; *Apiopterina*, pars, Zborzewski [1834].
Proroporus, pars, Ehrenberg [1844], Reuss.
Aulostomella, Alth [1850].
Grammostomum, pars; *Bigenerina*, pars; *Loxostomum*, pars; Ehrenberg [1854].
Pleurites, Ehrenberg [1854], Kübler and Zwingli.
Onchobotrys ? Ehrenberg [1856].
Rostrolina, *Atractolina*, pars, Schlicht [1869].

The genus *Polymorphina*, as its name implies, embraces a series of Foraminifera presenting great diversity of form. The typical shell is rounded and inequilateral in contour, its segments are few in number, obliquely set, and arranged in a more or less distinctly spiral manner, and the aperture is central and terminal. The various modifications of the type were arranged by d'Orbigny in four subgeneric groups, with the following characters.[1]

I. Polymorphina (proper), having a large number of chambers visible, alternating on two sides almost equally.
II. Guttulina, having but few of the chambers visible, alternating upon three faces; chambers embracing.
III. Globulina, alternating on three faces, chambers embracing; three chambers only visible.
IV. Pyrulina, alternation irregular or somewhat obscurely spiral, formed of half-embracing chambers.

It will be seen that, so far as external features are concerned, the foregoing subdivision depends on the number of segments in each convolution of the spire, whether

[1] *Ann. Sci. Nat.*, 1826, vol. vii. pp. 265–267.

two, three, or more; and also on their more or less embracing character, and the degree to which they are separated by the depression or excavation of the sutures. These sub-generic terms have been employed, with or without reservation, by most Continental writers, but they are at last falling into disuse, as it is found that they do not really facilitate the systematic treatment of the group, but rather the reverse. They are, however, of certain interest as indicating the principal lines of structural variation and the resulting modifications in external form. Thus the Pyruline and Globuline series have nearly regular *Lagena*-like tests with complanate sutures; the Guttuline forms have inflated segments, of which a larger number are visible, combined in a somewhat obscure triserial spire; whilst the modifications of *Polymorphina*, proper, range from the irregularly triserial to the biserial varieties, of which some of the latter approach *Textularia* itself in the symmetrical disposition of their segments.

The aperture of the test is placed near the centre of the distal end of the final segment, either even with the surface or in a mammillate protuberance. The orifice consists sometimes of a number of radiating fissures, sometimes of a round opening encircled by a collar of radiating grooves or of slightly raised lines. In exceptional cases it is found in the form of a circular, oval, or fissurine opening, without the radiating border; and occasionally it is subdivided into a number of small pores. In one somewhat anomalous species, *Polymorphina longicollis*, the nipple-like projection is developed into a tubular neck of some length, terminating in a phialine or radiate lip; and specimens are by no means rare, especially in the starved or poorly developed varieties, in which the aperture forms an entosolenian tube extending into the cavity of the final segment.

The exterior of the test is either smooth, or beset with setæ, spines, or tubercles, or with granular lines, parallel striæ, or raised costæ.

In one peculiarity the genus *Polymorphina* stands almost alone amongst Foraminifera, namely, the tendency displayed by the later segments to produce irregular fistulose outgrowths, as shown in Pl. LXXIII. figs. 14–17. These expansions are probably an evidence of redundant growth, and they assume a great diversity of aspect. The shelly investment is commonly very thin, and often rugose externally; the margins are extended into tubular and sometimes irregularly-branching processes, the open ends of which serve as orifices. Soldani devotes three entire plates of the Testaceographia to the illustration of these curious anomalous forms. The fistulose or cervicorn varieties have been treated by some writers as constituting collectively a distinct specific or even generic[1] group; but as almost all the commoner species of *Polymorphina* are found from time to time in this condition, it appears more natural to assign such modifications to their respective types, their true position being that of individuals of monstrous development. Prof. Reuss in his later works adopted the latter view, and it has been followed in the present Report.

[1] The genus *Aulostomella* of Alth, see *Haidinger's Naturw. Abhandl.*, 1850, vol. iii. p. 263.

The test of *Polymorphina* is almost invariably free; there is, however, little doubt that one species with somewhat exceptional characters, *Polymorphina concava*, Williamson, is parasitic when living; and the "cervicorn" varieties are not unfrequently found growing attached to foreign bodies.

The dimorphous modifications of *Polymorphina*, those in which the early spiral segments are succeeded by a straight or curved linear series, constitute the subgenus *Dimorphina* of d'Orbigny. Such forms are rare. As a group they correspond morphologically to *Sagrina* and *Clavulina*, the dimorphous representatives of *Uvigerina* and *Valvulina* respectively.

The geographical distribution of *Polymorphina*, within certain bathymetrical limits, is world-wide. It is found in the Arctic Seas, as far north as lat. 79° 35′ N., and in the opposite hemisphere nearly as far south as Kerguelen Island, lat. 46° 46′ S. It is essentially a shallow-water genus, and is most abundant at depths of less than 80 or 100 fathoms. At the same time there are certain forms of which fine examples are met with as low as 400 fathoms, and some of the smaller starved varieties are present even to depths of 2000 or 2500 fathoms.

The geological range of the genus extends back as far as the Upper Trias of Derbyshire (Jones and Parker), and the Raibl Beds of South Germany (Gümbel); it becomes tolerably common in the Lias, and thenceforward is found in microzoic rocks of every successive period.

Polymorphina lactea, Walker and Jacob, sp. (Pl. LXXI., typical, fig. 11; var., fig. 14).

"*Serpula* tenuis ovalis lævis," Walker and Boys, 1784, Test. Min., p. 2, pl. i. fig. 5.

"Polymorpha *Subcordiformia* vel *Oviformia*," Soldani, 1791, Testaceographia, vol. i. pt. 2 p. 114, pl. cxii. figs. *ll*, *nn*, &c.

Serpula lactea, Walker and Jacob, 1798 (*fide* Kanmacher), Adams's Essays, 2nd ed., p. 634, pl. xxiv. fig. 4.

Vermiculum lacteum, Montagu, 1803, Test. Brit., p. 522.

Polymorphina lactea, Macgillivray, 1843, Moll. Aberd., p. 320.

Arethusa lactea, Thorpe, 1844, Brit. Mar. Conch., p. 233.

Globulina lachryma, Reuss, 1845, Verstein. böhm. Kreid., pt. i., pp. 40, 110, pl. xiii. fig. 83.

Pyrulina ovulum, Ehrenberg, 1854, Mikrogeologie, pl. xxxi. figs. 35, 36.

Polymorphina muensteri, Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 249, pl. viii. fig. 80.

Globulina roemeri, Id. Ibid. p. 245, pl. vi. fig. 63.

Polymorphina lactea, typica (pars), Williamson, 1858, Rec. For. Gt. Br., p. 71, pl. vi. fig. 147.

„ *lactea*, var. *communis*, Id. Ibid. p. 72, pl. vi. figs. 153–155.

„ *lactea*, Brady, Parker, and Jones, 1870 (Monograph of Polymorphina), Trans. Linn. Soc. Lond., vol. xxvii. p. 213, pl. xxxix. fig. 1, *a–c*.

Fistulose form (Pl. LXXIII. fig. 14).

"Polymorpha *Corcula Spinosa*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 114, pl. cix. fig. *I.*, &c.

Misilus aquatifer, Montfort, 1808, Conch. Systém., vol. i. p. 294, 74e genre.

Apiopterina d'Orbigni, Zborzewski, 1834, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. iii. p. 311, pl. xxviii. fig. 2, *b*.

The typical *Polymorphina lactea* has an ovate or subpyriform, nearly symmetrical test, almost circular in transverse section, and with about four visible chambers; the chambers are elongate, and are set in an erect or somewhat oblique manner, and their sutures are slightly excavated externally. Such forms merge by insensible degrees into the globular *Polymorphina gibba*, on the one hand, and into the Pyruline type, *Polymorphina gutta*, on the other. Of the drawings, fig. 11 represents a typical specimen, corresponding accurately with Walker's original sketch; whilst fig. 14 (Pl. LXXI.) is an elongate individual that might almost be assigned to *Pyrulina gutta*, d'Orbigny (Ann. Sci. Nat., vol. vii. p. 267, pl. xii. figs. 5, 6;—Modèle, No. 30), and only differs from *Globulina minuta*, Roemer (see Reuss's figure, Denkschr. d. k. Akad. Wiss. Wien., vol. i. p. viii. fig. 8), by the absence of any lateral compression.

Polymorphina lactea is found to a greater or less extent in almost every sea, but it is most abundant and the specimens are better developed in comparatively shallow water and in temperate latitudes. In the North Atlantic the species has not been met with at a greater depth than about 400 fathoms, but in the South Atlantic it has been observed as low as 1990 fathoms, in the North Pacific at 2300 fathoms, and in the South Pacific at 2350 fathoms; but in all cases in which it occurs at great depths the specimens are rare and individually of exceedingly small size. Its area of distribution extends as far north as the shores of Novaya Zemlya, about lat. 73° N., whilst in the opposite hemisphere the Cape of Good Hope appears to be about its southern limit.

The first appearance of the species as a fossil is probably in beds of Jurassic age, namely, in the Kimmeridge Clay and the Upper Portland Limestone of the south of England (Parker and Jones). It occurs in the Cretaceous system of Bohemia and Russia, in the Lower and Middle Tertiaries of Northern and Central Germany and of England, in the Subapennine deposits of Italy, in the Crag of the eastern counties of England, and in the Post-tertiary formations of Scotland, Ireland, Norway, and Canada.

Polymorphina amygdaloides, Reuss (Pl. LXXI. fig. 13).

Globulina amygdaloides, (?) Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 82, pl. vi. fig. 47.

Polymorphina amygdaloides, Id. 1855, Sitzungsb. d. k. Akad. Wiss. Wien, vol. xviii. p. 250, l. viii. fig. 84.

Polymorphina subdilatata, Egger, 1857, Neues Jahrb. für Min., &c., p. 286, pl. xiii. figs. 30–33.
„ *depauperata*, Reuss, 1867, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lv. p. 89, pl. iii. fig. 9.
„ *lactea*, var. *amygdaloides*, Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 214, woodcuts.

The term *Polymorphina amygdaloides* is employed to distinguish the more or less flattened varieties of the typical *Polymorphina lactea*. The degree of lateral compression varies with every specimen, and almost every gradational step in the series has at one time or other been made the basis of a fresh "specific" name. Thus *Polymorphina minuta*, Roemer, is almost typical, that is to say, nearly round in transverse section; *Globulina guttula*, Reuss, is the same thing but a little more oval in section; *Polymorphina depauperata*, Reuss, is more distinctly compressed; and *Polymorphina amygdaloides*, Reuss, has flattened sides. Many other names have been employed either for intermediate forms or for specimens presenting slight irregularities of external contour, but they only serve to complicate an already overburdened nomenclature.

No separate account can be given of the distribution of such forms; wherever the type is found, more or less compressed or irregular modifications present themselves.

Polymorphina gibba, d'Orbigny (Pl. LXXI. fig. 12, *a.b.*).

"Polymorpha *Subcordiformia* vel *Oviformia*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 114, pl. cxiii. figs. *zz*, *C*, &c.
Polymorphina (*Globulina*) *gibba*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 266, No. 20;—Modèle, No. 63.
Globulina gibba, Id. 1846, For. Foss. Vien., p. 227, pl. xiii. figs. 13, 14.
„ *punctata*, Id. Ibid. p. 229, pl. xiii. figs. 17, 18.
„ *amplectens*, Reuss, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 81, pl. vi. fig. 44.
„ *inflata*, Id. Ibid. p. 81, pl. vi. fig. 45.
Polymorphina communis (pars), Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 283, pl. xi. fig. 32.
Polymorphina (*Globulina*) *gibba*, Egger, 1857, Neues Jahrb. für Min., &c., p. 288, pl. xiii. figs. 1–4.
„ „ „ var. β, *ovoidea*, Id. Ibid. p. 289, pl. xiii. figs. 6, 7.
„ „ „ var. γ, *subgibba*, Id. Ibid. p. 289, pl. xiii. figs. 8–10.
„ „ „ var. δ, *pyrula*, Id. Ibid. p. 290, pl. xiii. figs. 11, 12.
„ *lactea*, Parker and Jones, 1864, Phil. Trans., vol. clv. p. 359, pl. xiii. figs. 45, 46.
„ *gibba*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, pl. i. figs. 49–51.
„ *gibba*, var. *orbicularis*, Karrer, 1868, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lviii. p. 54 pl. iv. fig. 8.
Globulina subgibba, Gümbel, 1868, Abhandl. d. k. bayer. Akad. d. Wiss., II. Cl., vol. x. p. 645, pl. ii. fig. 79.
Rostrolina, sp., Schlicht, 1870, Foram. Pietzpuhl, p. 73, No. 415, pl. xxvi. figs. 25–27.
Polymorphina gibba, Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 216, pl. xxxix. fig. 2, *a–d*.

Fistulose form (Pl. LXXIII. fig. 16).

"Polymorpha *Corcula Spinosa*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 114, pl. cxi. fig. *Z*, &c.
Raphanulina humboldtii, Zborzewski, 1834, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. iii. p. 311, pl. xxviii. fig. 1, *a*.
Globulina tubulosa, d'Orbigny, 1846, For. Foss. Vien., p. 228, pl. xiii. figs. 15, 16.
Polymorphina orbignii (pars), Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. 27, p. 244, pl. xlii. figs. 38, *b. f.*

The shell of *Polymorphina gibba* in its typical condition is nearly spherical, generally somewhat produced at the apex and broad and rounded at the base. It usually presents three visible segments, which are compactly joined and overlapping; and the sutures are marked by fine lines, neither excavated nor depressed externally. Specimens exhibiting more or less lateral compression constitute the *Globulina æqualis* of d'Orbigny (For. Foss. Vien., p. 227, pl. xiii. figs. 11, 12), whilst those which are of oblate contour, that is to say, compressed in the direction of the axis, form the *Polymorphina gibba*, var. *orbicularis* of Karrer.

The shape of the anterior or oral end of the test differs a good deal in different individuals. In some it is acuminate and the orifice is situated on a mammillate protuberance; in others it is truncate, and the general aperture is flush with the body of the shell; and in rare examples the orifice is inverted so as to form an entosolenian tube, as in some of the *Lagenæ*.

Polymorphina gibba cannot be separated from the typical *Polymorphina lactea*, except in a very indefinite manner by comparative characters, and the remarks that have been made concerning the distribution of the latter species apply equally to the present form. Its occurrence as a fossil has perhaps been even more frequently recorded, nevertheless the ascertained geological range is practically the same, namely, from the Oolitic period to Post-tertiary and recent times.

Polymorphina sororia, Reuss (Pl. LXXI. figs. 15, 16).

Polymorphina (*Guttulina*) *sororia*, Reuss, 1862, Bull. Acad. Roy. Belg., sér. 2, vol. xv. p. 121, pl. ii. figs. 25–29.
" " " Id. 1870, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lxii. p. 487, No. 9.—Schlicht, 1870, Foram. Pietzpuhl, pl. xxvi. figs. 4–12, 16, 18, &c.

Fistulose form (Pl. LXXIII. fig. 15).

Globulina horrida, Reuss, 1846, Verstein. böhm. Kreid., pt. ii. p. 110, pl. xliii. fig. 14.
Aulostomella pediculus, Alth, 1850, Haidinger's Naturw. Abhandl., vol. iii. p. 264, pl. xiii. fig. 17.

This is another variety scarcely separable from the typical *Polymorphina lactea*, and differing from the latter chiefly in its elongate and subfusiform contour.

Polymorphina sororia is less common than the type, but it has a similarly wide area of distribution.

Polymorphina sororia, var. *cuspidata*, nov. (Pl. LXXI. figs. 17–19; Pl. LXXII. fig. 4).

A variety presenting the same general features as *Polymorphina sororia*, but more distinctly fusiform, and terminating at the initial end in a stout spine.

This form has been met with at two points in the North Atlantic, west of Ireland, depth 808 fathoms and 1443 fathoms respectively; and at Station 146, about midway between the Cape of Good Hope and Kerguelen Island, 1375 fathoms.

Polymorphina angusta, Egger (Pl. LXXII. figs. 1–3).

Polymorphina (*Globulina*) *angusta*, Egger, 1857, Neues Jahrb. für Min., &c., p. 290, pl. xiii. figs. 13–15.

Polymorphina lanceolata, (pars) Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 487, No. 12;—Schlicht, 1870, Foram. Pietzpuhl., pl. xxxi. figs. 2, 3, 4, &c.

„ *gracilis*, Id. Ibid., p. 486, No. 7;—Schlicht, pl. xxxi. figs. 34–45, &c.

„ *fusiformis* (pars), Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 219.

In the Monograph of the genus (Trans. Linn. Soc., vol. xxvii.), the small, starved, deep-water variety, of which the specimen figured by Egger (*loc. cit.*), is a good example, was treated as one of the modifications of *Polymorphina fusiformis;* but the subsequent study of a somewhat large series of recent specimens has led to the conclusion that it possesses tolerably well-marked characters which it may be convenient to recognise by a distinctive name.

In its typical condition, the test of *Polymorphina angusta* is of elongate-oval or subcylindrical contour, with obtuse or rounded extremities, or sometimes pointed at the primordial end. It is usually composed of about four segments, which are long and erect; the shell-wall is delicately thin and transparent, and the sutures are marked externally by fine lines. A more striking peculiarity is afforded by the fact that not unfrequently the septal walls are absorbed, so that the interior forms an undivided cavity. Specimens in this condition are often only distinguishable from varieties of *Lagena lævis* by the remains of the external sutures; and the generic resemblance is frequently enhanced by the presence of a short entosolenian tube.

Polymorphina angusta is a widely diffused species. It occurs both in the North and South Atlantic, and in the North and South Pacific; and though it most affects deep water, that is to say, bottoms ranging from 1000 to 2400 fathoms, it occurs also, from time to time, in shallower dredgings.

As a fossil it has been found in the Miocene of Lower Bavaria (Egger), and in the Septaria-clays of Germany (Schlicht).

Polymorphina lanceolata, Reuss (Pl. LXXII. figs. 5, 6).

Polymorphina lanceolata, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 83, pl. vi. fig. 50.
Guttulina cylindrica, Bornemann, 1855, Ibid. vol. vii. p. 347, pl. xviii. figs. 4–6.
Polymorphina prælonga, Egger, 1857, Neues Jahrb. für Min., &c., p. 287, pl. xiii. figs. 25–27.
„ *subteres*, Reuss, 1860, Sitzungsb. d. k. Akad. Wiss. Wien, vol. xlii. p. 361, pl. ii. fig. 14.
„ *lanceolata* (pars), Id., 1870, Ibid. vol. lxii. p. 487, No. 12;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxxi. figs. 5, 6, &c.
„ *fusiformis* (pars), Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 219, pl. xxxix. fig. 5, *b.c.*

In the memoir on the *Polymorphinæ* already referred to, the elongated forms constituting the *Polymorphina lanceolata* of Reuss, together with the more oval varieties last described, were included with certain similar but shorter tapering modifications in one common group, of which the *Polymorphina fusiformis* of Roemer was adopted as the type. Reuss's notes on the comprehensive series of figures of *Polymorphinæ* in von Schlicht's illustrations of Tertiary Foraminifera supply a favourable basis for the reconsideration of many points in connection with the specific grouping of the genus, and they appear to warrant the retention of *Polymorphina lanceolata* as a distinctive term in the sense in which it was originally employed.

In its typical condition the test of this species is elongate and cylindrical or somewhat compressed, and it tapers to a point at the inferior extremity; it seldom has more than six segments, and the sutures are little, if at all, excavated externally; the apertural end is tapering and bluntly pointed. The aperture is commonly radiate, but in exceptional cases it takes the form of a simple rounded orifice in a short, produced neck, and in rare examples it is furnished with an entosolenian tube.

Polymorphina lanceolata represents a starved condition of the genus, and like the foregoing closely allied species, it has a wide area of distribution. Its maximum depth appears to be about 1825 fathoms.

If one may judge from M. Terquem's drawings (Foram. du Lias, 4ième Mém., pls. xi.–xiv.), some of the Liassic *Polymorphinæ* may very properly be assigned to the present species; but setting aside the somewhat ill-defined Mesozoic forms, its ascertained geological range is limited to the middle and later Tertiary formations of Central Europe.

Polymorphina ovata, d'Orbigny (Pl. LXXII. figs. 7, 8).

Polymorphina ovata, d'Orbigny, 1846, For. Foss. Vien., p. 233, pl. xiii. figs. 1–3.
„ „ Reuss, 1867, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lv. p. 91.

The test of this species has an oval but somewhat inequilateral outline, and the two faces are almost equally convex; the oral end is obtuse, the aboral acuminate; the segments

are arranged with regularity in two alternating series, the last pair occupying two-thirds of the visible shell; the sutures are complanate and are marked by fine lines without external depressions. D'Orbigny's figures (*loc. cit.*), scarcely convey a correct impression of the appearance of the shell, at any rate of recent specimens, which are distinguished primarily by their smooth, convex, lateral faces and flush sutures, and by the very large size of the final segments. In the Monograph of the Genus Polymorphina (Trans. Linn. Soc. Lond., vol. xxvii. p. 227) the species was erroneously placed in the synonymy of *Polymorphina compressa*.

Living examples of *Polymorphina ovata* have been obtained from only one Challenger Station—off Culebra Island, West Indies, 390 fathoms.

The habitat given with the original specimens is the Miocene of Nussdorf, near Vienna. Reuss furnishes the following additional localities, all referrible to Middle Tertiary formations,—the Salt-clay of Wieliczka in Galicia, the Leithakalk of the Vienna Basin, and the Gypsum-bearing marl of Kathrein in Moravia.

Polymorphina compressa, d'Orbigny (Pl. LXXII. figs. 9–11).

"Polymorpha *Subovalia*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 114, pl. cxiv. figs. *F*, *I*, pl. cxv. fig. *N*; pl. cxvi. figs. *V*, *X*, &c.

Polymorphina compressa, d'Orbigny, 1846, For. Foss. Vien., p. 233, pl. xii. figs. 32–34.

„ *prisca*, Ehrenberg, 1854, Mikrogeologie, pl. xxiv. fig. 34.

Grammostomum gracile, Id. Ibid. pl. xxvii. fig. 25.

Loxostomum vorax, Id. Ibid. pl. xxviii. fig. 24.

Bigenerina apiculata, Id. Ibid. pl. xxviii. fig. 23.

„ *libanotica*, Id. Ibid. pl. xxv. I. A., figs. 25, 26.

Pleurites turgens, Id. Ibid. pl. xxxi. fig. 37.

„ *? americanus*, Id. Ibid. pl. xxxii. II., fig. 20.

Polymorphina insignis, Reuss, 1855, Sitzungsb. d. k. Akad. Wiss. Wien, vol. xviii. p. 248, pl. vii. figs. 74, 75.

„ *media*, Egger, 1857, Neues Jahrb. für Min., &c., p. 287, pl. xiii. figs. 28, 29.

Globulina discreta, Reuss, 1864, Sitzungsb. d. k. Akad. Wiss. Wien, vol. l. p. 468, pl. iii. fig. 3.

Guttulina robusta, Id. Ibid. p. 470, pl. iii. figs. 5–7.

Polymorphina angustata, Terquem, 1864, Foram. du Lias, 4ième mém., p. 296, pl. xii. figs. 33, 34.

„ *sinuata*, Id. Ibid. p. 298, pl. xii. fig. 48.

„ *sacculus*, Stache, 1865, Novara-Exped., geol. Theil, vol. i. pt. 2, Paläont., p. 259, pl. xxiv. fig. 6.

„ *incavata*, Id. Ibid. p. 260, pl. xxiv. fig. 7.

„ *lactea*, var. *compressa* (pars), Parker and Jones, 1865, Phil. Trans., vol. clv. p. 361, pl. xiii. figs. 47, 49, 51.

„ *compressa*, Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 227, pl. xl. fig. 12, *a–f*.

Fistulose form (Pl. LXXIII. fig. 17).

Polymorphina lactea, var. *fistulosa*, Williamson, 1858, Rec. For. Gt. Br., p. 72, pl. vi. fig. 150.
„ „ var. *tubulosa*, Parker and Jones, 1862, Introd. Foram., App., p. 311.
„ *orbignii* (pars), Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 244, pl. xlii. fig. 38, *d*.

The test of this species is irregularly oval or oblong and much compressed, but it varies a good deal as to proportionate length and breadth. The segments are disposed in two, generally unequal, alternating series, and are marked externally by excavated sutures. The surface of the shell is smooth, in rare cases exhibiting a few faint longitudinal striæ near the initial end. It sometimes attains a length of $\frac{1}{8}$th inch (3·15 mm.) or even more.

In general terms *Polymorphina compressa* may be said to include the less regularly Textulariform varieties of the genus, its nearest allies being *Polymorphina complanata*, d'Orbigny, *Polymorphina frondiformis*, S. V. Wood, and *Polymorphina cylindroides*, Roemer. Of these the first is distinguished by the exceedingly regular and equilateral *Textularia*-like disposition of the segments, and *Polymorphina frondiformis* by its even larger dimensions and its surface-ornament of interrupted costæ or tubercles; whilst *Polymorphina cylindroides* has a long tapering test, less compressed than that of the present species and composed of a small number of nearly erect segments.

Polymorphina compressa is a cosmopolitan form, especially common in temperate latitudes; nevertheless, it has been found as far north as lat. 79° 35′ N., in Smith Sound, and at lat. 73° N. or thereabouts, on the shores of Novaya Zemlya. It is abundant in the temperate portion of the North Atlantic, preferring shallow-water margins, but extending sometimes to a depth of 400 or even 600 fathoms. In the tropical South Atlantic, and in the North and South Pacific, it is less frequent.

It has been recognised as a fossil in the Lower and Middle Lias of the west and north of England (Brady, Blake); in the Lower Oolite, the Upper Oxford Clay, and the Kimmeridge Clay of England (Parker and Jones), in the Cretaceous system of England, France, Germany, and North America, and generally in the Tertiary and Post-tertiary formations of Europe.

Polymorphina elegantissima, Parker and Jones (Pl. LXXII. figs. 12–15).

Polymorphina elegantissima, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 438.
„ „ Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 231, pl. xl. fig. 15, *a–c*.

The typical *Polymorphina elegantissima* differs from its congeners chiefly in the arrangement of the segments, the general plan of which is regularly biserial, but the alternation is inequilateral. The test consists of two alternating series of chambers, set obliquely to each other, in such a way that on each face of the shell one series is hidden by the overlap of its

large terminal segment,—the series that is exposed on one face of the shell being covered on the other, and *vice versâ*. Thus, from whichever side the test is viewed, it presents four or five arcuate chambers, with their ends embraced by the broad final segment of the opposing series. The test is sometimes more or less compressed on three sides, but the same general arrangement of the segments is preserved.

In point of distribution the species appears to be confined to the shores of the Pacific, and is best known from Australian specimens. It has been found in littoral sands from the neighbourhood of Melbourne, and in dredged material from Port Jackson and Sydney Heads, New South Wales; from Curtis Strait, Queensland; from Bass Strait, 38 fathoms; from Torres Strait, 155 fathoms; and from Storm Bay, Tasmania. It has also been obtained off Ki Islands, 129 fathoms and 580 fathoms, and in Hong Kong Harbour, 7 fathoms.

Some of the specimens figured by Reuss as *Polymorphina problema*, var. *deltoidea*, and *Polymorphina anceps* (Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. pl. iv. figs. 8–11), and by Schlicht (Foram. Pietzpuhl, pl. xxxii. figs. 17–20), from the Septaria-clays of Germany, appear to me to be inseparable from this species.

Polymorphina seguenzana, n. sp. (Pl. LXXII. figs. 16, 17).

Test elongate, fusiform, compressed on three sides; broadest somewhat below the centre, tapering gradually towards the oral end, and somewhat more rapidly towards the opposite extremity, which finishes in a sharp point: segments few in number, only three visible externally, long, narrow, erect; surface smooth, sutures marked by fine lines without external depressions. Length, $\frac{1}{16}$th inch (1·6 mm.).

The trifacial compression of the test, its acuminate initial end, and the erect position of the segments, are sufficient to distinguish this species from its near allies. It has been named after Prof. Seguenza of Messina, to whom science is indebted for several important palæontological memoirs bearing more or less upon the Foraminifera.

Polymorphina seguenzana is exceedingly rare, having only been observed in two localities, namely,—off the Ki Islands, south-west of New Guinea, depth, 129 fathoms, and at Port Jackson, New South Wales, 2 to 10 fathoms.

Polymorphina thouini, d'Orbigny (Pl. LXXII. fig. 18).

Polymorphina thouini, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 265, No. 8.—Modèle, No. 23.
„ „ Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 232, pl. xl. fig. 17.

This is an attenuated variety, with long, nearly erect, slightly inflated segments. The d'Orbignian model has fewer chambers than the specimens represented in fig. 18, and is even longer proportionately.

Polymorphina thouini is a rare form, and in the recent condition has only been observed in the Levant, 90 fathoms, and off East Moncœur Island, Bass Strait, 38 fathoms.

As a fossil it occurs in the Eocene of the Paris Basin, in the Pliocene clays of Northern Italy, and in the Crag of Suffolk.

Polymorphina problema, d'Orbigny (Pl. LXXII. fig. 20; Pl. LXXIII. fig. 1).

Polymorphina (*Guttulina*) *problema*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 266, No. 14.—Modèle, No. 61.
„ „ *crassatina*, Münster, 1838 (*fide* Roemer), Neues Jahrb. für Min., &c., p. 385, pl. iii. fig. 30.
„ „ *spicæformis*, Roemer, 1838 Ibid. p. 386, pl. iii. fig. 31.
Guttulina problema, d'Orbigny, 1846, For. Foss. Vien., p. 224, pl. xii. figs. 26–28.
„ *austriaca*, Id. Ibid. p. 223, pl. xii. figs. 23–25.
Polymorphina uvula, Ehrenberg, 1854, Mikrogeologie, pl. xxvi. fig. 28.
„ „ Egger, 1857, Neues Jahrb. für Min., &c., p. 285, pl. x. figs. 26–29.
Guttulina rotundata, Reuss, 1864, Sitzungsb. d. k. Akad. Wiss. Wien, vol. l. p. 469, pl. iii. fig. 4.
„ *pusilla*, Stache, 1865, Novara-Exped., geol. Theil, vol. i. pt. 2, p. 265, pl. xxiv. fig. 12.
Polymorphina problema, Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 225, pl. xxxix. fig. 11, *a.b.*

Polymorphina communis, d'Orbigny (Pl. LXXII. fig. 19).

Polymorphina (*Guttulina*) *communis*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 266, pl. xii. figs. 1–4.—Modèle, No. 62.
Guttulina vitrea, Id., 1839, Foram. Cuba, p. 128, pl. ii. figs. 1–3.
„ *communis*, Id., 1846, For. Foss. Vien., p. 224, pl. xiii. figs. 6–8.
Globulina irregularis, Id. Ibid. p. 226, pl. xiii. figs. 9, 10.
Guttulina cretacea, Alth, 1849, Haidinger's Naturw. Abhandl., vol. iii. p. 262, pl. xiii. fig. 14.
„ *semiplana*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 82, pl. vi. fig. 48.
Polymorphina (*Guttulina*) *communis*, Egger, 1857, Neues Jahrb. für Min., &c., p. 288, pl. xiii. figs. 16–18.
„ „ *lata*, Id. Ibid. p. 288, pl. xiii. figs. 22–24.
Guttulina fissurata, Stache, 1865, Novara-Exped., geol. Theil, vol. i. part 2, p. 263, pl. xxiv. fig. 10.
„ *obliquata*, Id. Ibid. p. 264, pl. xxiv. fig. 11.
Polymorphina semiplana, Reuss, 1870, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lxii. p. 488, No. 16.—Schlicht, 1870, Foram. Pietzpuhl, pl. xxvii. figs. 22–33, &c.
„ *problema*, var. *communis*, Id. Ibid., p. 487, No. 15.—Schlicht, pl. xxx. figs. 13–16.
„ *communis*, Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 224, pl. xxxix. fig. 10, *a.b.*

D'Orbigny's Models, Nos. 61 and 62, portray what appear at first sight two tolerably well-marked varietal forms. The former, that of *Polymorphina problema*, presents about

seven visible segments which are individually much inflated, and the sutures correspondingly depressed externally; whilst the latter, *Polymorphina communis*, has only four or five visible segments, of which the sutures are excavated in a less degree. These characters, however, are soon found to be the result of mere individual peculiarity, and beyond that to have little or no distinctive value.

In the "Vienna Basin" memoir both forms are included, and the terms in which they are described are so nearly alike as to be practically useless for the identification of specimens. It may be inferred, however, that the shell of *Polymorphina communis* is of smaller size, that the superior end is acuminate (the oral extremity of *Polymorphina problema* being obtuse), and that the sutures are complanate—none of which are very noteworthy distinctions.

Reuss, in his notes on Herr von Schlicht's Septaria-clay Foraminifera, one of the lamented author's latest contributions to the literature of the Rhizopoda, treated *Polymorphina communis* as a variety of *Polymorphina problema*.

Practically it is quite impossible, with a number of specimens under examination, to say by any rule how they should be apportioned between the two "species," and under these circumstances the recognition of both appears needless complication of the nomenclature. *Polymorphina problema*, which obviously represents the more fully developed form, might with advantage be adopted as the type of the group, and the term "*communis*" allowed to lapse.

In like manner the two forms are closely associated in their distribution, which either from a geographical, bathymetrical, or a geological point of view, affords no basis for separate treatment. They are found in the littoral, laminarian, coralline, and coral zones of almost every latitude, reaching as far north as lat. 79° 26′ N., and southwards at any rate to Tristan da Cunha and the Cape of Good Hope. The greatest depth at which they have been observed is 155 fathoms.

The same varieties are recorded from the Lower Lias (Blake); they are also well represented in the Chalk, and in marine formations of almost every later geological age.

Polymorphina oblonga, d'Orbigny (Pl. LXXIII. figs. 2–4).

Polymorphina oblonga, d'Orbigny, 1846, For. Foss. Vien., p. 232, pl. xii. figs. 29–31.
„ *uvæformis*, Reuss, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 289, fig. 5.
„ *guttata*, Id. 1870, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lxii. p. 487.—Schlicht, 1870, Foram. Pietzpuhl, pl. xxx. figs. 25–32.

This is an elongate variety, with characters intermediate between those of *Polymorphina problema* and *Polymorphina compressa*. The test is more or less compressed, and has six to eight visible segments, which are somewhat oblong and inflated in contour, and

separated by excavated sutures. It is not to be confounded with the *Polymorphina lactea*, var. *oblonga*, of Williamson, which has an oval compressed shell with erect segments and flush sutures.

The distribution of *Polymorphina oblonga*, whether geographical or geological, is similar to that of the allied forms already named, with which indeed it is generally found associated. It seldom occurs at greater depth than five hundred fathoms, but the fistulose modification has been met with at one point in the North Pacific as low down as 2050 fathoms.

Polymorphina rotundata, Bornemann, sp. (Pl. LXXIII. figs. 5–8).

Guttulina rotundata, Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 346, pl. xi. pl. xviii. fig. 3.

„ *incurva*, Id. Ibid. p. 345, pl. xvii. fig. 6.

„ *fracta*, Id. Ibid. p. 344, pl. xvii. fig. 4.

„ *dimorpha*, Id. Ibid. p. 345, pl. xvii. fig. 5.

Polymorphina tenera, Karrer, 1868, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lviii. p. 174, pl. iv. fig. 9.

Rostrolina, sp., Schlicht, 1870, Foram. Pietzpuhl, p. 72, No. 412, pl. xxvi. figs. 13–15, &c.

Polymorphina rotundata, Reuss, 1870, Sitzungsb. d. k. Akad. Wiss. Wien, vol. lxii. p. 487, No. 14.—Schlicht, *op. cit.*, pl. xxvi. figs. 13–15; pl. xxviii. figs. 1–5; pl. xxx. figs. 33–40.

„ *turgida*, Id. Ibid., p. 487, No. 10.—Schlicht, pl. xxviii. figs. 6–10; pl. xxix. figs. 1–5.

„ *rotundata*, Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 234, pl. xl. fig. 19 *a–e*, and woodcuts.

This is an exceedingly variable form, and one which it is almost impossible to describe in definite zoological terms, though it exhibits a certain habit of growth that is seldom difficult to identify. Referring to the illustrations,—figures 7 and 8 are drawn from nearly typical examples; and between these and extreme varieties like figures 5 and 6, specimens exhibiting every gradation of contour and structure are met with wherever the species abounds. Of such individual modifications Bornemann (*loc. cit.*), makes several "species;" but the still larger array of drawings furnished by von Schlicht are grouped by Reuss under only two names, *Polymorphina rotundata* and *Polymorphina turgida*. Between the latter I can find no serviceable mark of distinction, taken together they form a natural and convenient quasi-specific group.

Polymorphina rotundata is not common in the living condition. A few specimens have been collected in the British seas, off the west coast of Scotland (Robertson) and the north-east of Ireland; and in the Mediterranean, off Malta. It occurs more plentifully in the Southern Ocean, off Prince Edward Island, 50 to 150 fathoms; also at one Station in the North Pacific, depth 1850 fathoms; and at one in the South Pacific, 1825 fathoms.

The species is best known as a Tertiary fossil, being a common constituent of the Septaria-clays of various parts of Germany.

Polymorphina myristiformis, Williamson (Pl. LXXIII. figs. 9, 10).

Polymorphina (*Globulina*) *sulcata*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 266, No. 21. Name only [*fide* Fischer].
Polymorphina myristiformis, Williamson, 1858, Rec. For. Gt. Br., p. 73, pl. vi. figs. 156, 157.
" " Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 240, pl. xli. fig. 30, *a.c.*
" " Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 391, No. 26.

This pretty, bright, little shell resembles *Polymorphina gibba* in general contour, but it is decorated externally with lines of tubercles or with irregular and interrupted costæ. In exceptional cases the costæ are almost continuous and the general aspect of the test approaches that of *Lagena sulcata;* but it is easily distinguished by its gibbous outline and radiate aperture, even when the septation happens to be obscured by abnormally thick walls.

Polymorphina myristiformis is not uncommon in the British seas, at depths of more than 30 fathoms, and it is found also on the shores of Belgium and France. Its occurrence has been recorded at one Station in the North Atlantic, south of Rockall Bank, at a depth of 630 fathoms.

Fossil specimens of this species have been obtained from the Barton Beds (Lower Tertiary) of the Isle of Wight, and the Miocene of Pont-de-Voy, France; and Mr. Wright notes its occurrence in the sub-recent estuarine clays of the north-east of Ireland.

Polymorphina regina, Brady, Parker, and Jones (Pl. LXXIII. figs. 11–13).

Polymorphina regina, Brady, Parker, and Jones, 1870, Trans. Linn. Soc. Lond., vol. xxvii. p. 241, pl. xli. fig. 32, *a.b.*

In the form and disposition of the segments, as well as in general contour, this species resembles *Polymorphina problema* and *Polymorphina oblonga*, but it is distinguished from its congeners by the superficial ornament of regular, closely-set, longitudinal costæ.

The distribution of *Polymorphina regina* appears to be limited to comparatively shallow water in the neighbourhood of the islands of the Pacific. The following are the points at which it has been observed:—Port Jackson, 6 fathoms, Sydney Heads, and Port Stephens, all in New South Wales; Curtis Strait, Queensland; Bass Strait, 38 fathoms; Storm Bay, Tasmania; Torres Strait, 155 fathoms; off Ki Islands, 129 fathoms; off Admiralty Islands, 17 fathoms; and off Honolulu, Sandwich Islands, 40 fathoms.

Under the name *Polymorphina semicostata* (Mittheil. naturw. Vereine v. Neu-Vorpom.

u. Rügen, Jahrg. x. p. 150, pl. ii. fig. 19) Marsson has figured an interesting varietal modification of the present species, in which the costæ are less prominent and are confined to the inferior portion of the chambers. His specimens were from the Cretaceous beds of the Island of Rügen. The form recorded by Wright as "*Polymorphina regina*, var." (Report and Proc. Belfast Nat. Field Club, 1873–4, App. p. 86) from the Chalk of the north-east of Ireland, belongs to the same variety.

Polymorphina longicollis, H. B. Brady (Pl. LXXIII. figs. 18, 19).

Polymorphina lanceolata, pars, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 487, No. 12.—Schlicht, 1870, Foram. Pietzpuhl, pl. xxxi. figs. 25–28, &c.
,, *longicollis*, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N.S., p. lxiv.

Test elongate-ovate, subcylindrical, or fusiform; segments few, three to five visible externally, erect, slightly inflated; surface more or less hispid, rarely smooth; the final segment, which is generally more inflated and more setose than the rest, terminating in a long apertural neck with everted and sometimes radiate lip. Length, $\frac{1}{40}$th inch (0·6 mm.).

This is an exceedingly interesting connecting link between the genera *Polymorphina* and *Uvigerina*. The general conformation of the shell is that of *Polymorphina*, whilst the long neck and phialine lip are typically Uvigerine features.

The morphological characters of the test are tolerably constant, but the condition of the exterior varies a good deal. Sometimes the entire surface is hispid, as in fig. 19; sometimes, on the other hand, it is smooth and devoid of spines; but in the majority of cases the earlier portions are smooth or nearly so, and only the final segment presents a setose exterior.

Polymorphina longicollis is essentially a deep-water Foraminifer, and the number of specimens found in any one locality is as a rule very small. It has not hitherto been met with at a less depth than 1100 fathoms. The following is the record of its distribution:—North Atlantic, three Stations, 1125 fathoms, 1476 fathoms, and 2435 fathoms respectively, at the last-named depth the specimens were non-spinous; South Atlantic, Station 338, depth 1990 fathoms, the best examples of the species; South Pacific, four Stations, depth 1375 fathoms, 1825 fathoms, 2075 fathoms, and 2425 fathoms respectively.

Amongst von Schlicht's illustrations of the Foraminifera of the Septaria-clay of Pietzpuhl (*loc. cit.*), are three or four figures of smooth-shelled specimens which may without any doubt be assigned to this form. They are referred to by Prof. Reuss as "*Polymorphina lanceolata*, mit röhrenförmiger und am Ende kurz verästalter Mündung."

Uvigerina, d'Orbigny.

Polymorpha, pars, Soldani [1791].
Uvigerina, d'Orbigny [1826], Reuss, Czjzek, Costa, Egger, Parker and Jones, Williamson, Carpenter, Karrer, Brady, Alcock, M. Sars, Schwager, &c.

The ordinary external aspect of the test in the genus *Uvigerina* is that of a more or less elongated spire, having three segments to each convolution and terminating in a tubulated aperture with an everted lip. The normal triserial arrangement is by no means constant, and some varieties are met with in which each whorl is composed of more than three segments, whilst on the other hand there are certain forms that exhibit a biserial or Textularian mode of growth. Dimorphous modifications of the typical structure, consisting of a small spiral shell surmounted by a uniserial line of segments, constitute the subordinate generic group, *Sagrina*.

In contour, the test of *Uvigerina* is typically ovate or slightly tapering; occasionally it is trifacial, with three more or less angular longitudinal edges; and in rare instances it is bifacial and compressed. The walls are calcareous, perforate, and hyaline, never sandy. They are seldom smooth externally, but usually bedecked with surface-ornament which takes the form of raised longitudinal costæ, fine striæ, spines, or minute prickles. Occasionally an intermediate condition is exhibited, in which the costæ are interrupted and part of them broken up into rows of tubercles or spines, as shown in Pl. LXXIV. figs. 24–26.

The genus *Uvigerina* is nearly related to *Polymorphina*, but apart from other distinctive characters the difference in their respective apertures is generally sufficient for their identification. The orifice of *Polymorphina* is surrounded by radiating lines, whilst that of *Uvigerina*, whether sessile or tubulated, is furnished with a thickened rim or a phialine lip.

The geographical distribution of *Uvigerina* extends from the most northerly points of the Arctic Ocean to the equator, and from the equator to the Antarctic Ice-barrier, and its presence has been noted at every depth down to 2600 fathoms or more. Its geological history, so far as is known, commences with the Eocene formations of the Bavarian Alps and of the vicinity of Paris, and reaches forward to the latest Glacial and Post-tertiary deposits of northern Europe.

Uvigerina canariensis, d'Orbigny (Pl. LXXIV. figs. 1–3).

"Testæ pineiformes minusculæ," Soldani, 1798, Testaceographia, vol. ii. p. 18, pl. iv. figs. *E*, *F*, *G*, *H*.
Uvigerina nodosa, var. *β*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 269, No. 3.
„ *canariensis*, Id. 1839, Foram. Canaries, p. 138, pl. i figs. 25–27.

Uvigerina urnula, d'Orbigny, 1846, For. Foss. Vien., p. 189, pl. xi. figs. 21, 22.
„ *irregularis*, Brady, 1865, Nat. Hist. Trans. Northd. and Durham, vol. i. p. 100, pl. xii. fig. 5.
„ *proboscidea*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 250, pl. vii. fig. 96.
„ *farinosa*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 62, pl. vii. fig. 6.

With some allowance for variability of outline, the *Uvigerina canariensis* of d'Orbigny serves as a good type of the smooth-shelled members of the genus. Such forms are not nearly so common as the costate and aculeate species, and it is seldom that their tests are quite so regularly triserial as depicted in the original figure. Sometimes the earlier segments are faintly ribbed externally, as shown in d'Orbigny's drawings of *Uvigerina urnula*, but this is a character of so little importance that it is not even mentioned in the Latin description of that form.

The distribution of the species, so far as at present known, is as follows :—off Bermuda, 435 fathoms; shore-sand Teneriffe (d'Orbigny); South Atlantic, east of Buenos Ayres, 1900 fathoms; off the Cape of Good Hope, 150 fathoms; and at five Stations in the South Pacific, 40 fathoms to 1375 fathoms, notably amongst the islands on the west coast of Patagonia. It has been found both by Mr. Siddall and myself on the British coast, and by the Rev. A. M. Norman in the North Atlantic, on the line of the Falmouth and Lisbon telegraph-cable.

D'Orbigny's fossil specimens (*Uvigerina urnula*) were obtained from the Miocene of the Vienna Basin; von Hantken's (*Uvigerina farinosa*), from the lower *Clavulina-szabói* beds of Ofen, Hungary; and Schwager's (*Uvigerina proboscidea*) from the Pliocene of Kar Nicobar. I have also a note of its occurrence in the Crag of the east of England.

Uvigerina tenuistriata, Reuss (Pl. LXXIV. figs. 4–7).

Uvigerina tenuistriata, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 485.—Schlicht, 1870, Foram. Pietzpuhl, pl. xxii. figs. 34–36.

Von Schlicht has figured (*loc. cit.*) specimens very similar to those portrayed in Pl. LXXIV. figs. 6, 7, but scarcely so well characterised; and von Reuss has assigned to them the name *Uvigerina tenuistriata*, adding a remark, that, after all, it is very possible the species is only a finely striate variety of the polymorphic *Uvigerina pygmæa*. In this latter view I entirely coincide; nevertheless the variety is better defined than many forms generally accepted as distinct, and it has in addition some peculiarities of distribution.

Uvigerina tenuistriata occurs in the Southern Ocean, off Heard Island, 75 fathoms; amongst the islands on the west coast of Patagonia, 40 to 140 fathoms; off Raine Island, Torres Strait, 155 fathoms; and off the Philippine Islands, 95 fathoms.

The fossil specimens above referred to were from the Tertiary Septaria-clay of Pietzpuhl, near Madgeburg.

Uvigerina pygmæa, d'Orbigny (Pl. LXXIV., Typical form, figs. 11–12; elongate variety, figs. 13, 14).

"Polymorpha *Pineiformia*," Soldani, 1791, Testaceographia, vol. i. pt. 2, pl. cxxx. figs. *ss*, *tt*.
Uvigerina pygmæa, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 269, pl. xii. figs. 8, 9.—Modèle, No. 67.
„ *bifurcata*, Id. 1839, Foram. Amér. Mérid., p. 53, pl. vii. fig. 17.
„ *pygmæa*, Id. 1846, For. Foss. Vien., p. 190, pl. xi. figs. 25, 26.
„ *semiornata*, Id. Ibid. p. 189, pl. xi. figs. 23, 24.
„ *striata*, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 266 pl. xv. fig. 3.
„ *pygmæa*, Williamson, 1858, Rec. For. Gt. Br., p. 66, pl. v. figs. 138, 139.
„ „ Parker and Jones, 1865, Phil. Trans., vol. clv. p. 363, pl. xiii. figs. 53–57; pl. xvii. fig. 65.

Uvigerina pygmæa is one of the best known and most easily recognised of recent Foraminifera. The test is commonly of the broadly ovate form represented in figs. 11 and 12; the surface is ornamented with stout, well-defined, raised costæ, and the shell-wall is thick and frequently of a brownish colour, but never sandy. Occasionally the shell assumes the more slender and elegant contour indicated by figs. 13 and 14. Intermediate specimens in which the exogenous ribs are partially replaced by rows of spines are not unfrequently met with, and serve to connect the typical costate form with the aculeate varieties. Drawings of some of these passage-forms are furnished in Pl. LXXIV. figs. 24–26 and Pl. LXXV. fig. 3.

The geographical distribution of the species extends over almost the whole world. It is common in the North and South Atlantic, in the Mediterranean and the Adriatic, and in the South Pacific, and rare only in the North Pacific. Its area extends from Smith Sound and the shores of Franz-Josef Land, lat. 79° N., to about lat. 46° S. in the Southern Ocean, and its bathymetric range from 2 fathoms to 2600 fathoms.

As a fossil it occurs in deposits of Miocene age in the neighbourhood of Vienna (d'Orbigny, Karrer), and in Lower Bavaria (Egger); in the *Clavulina-szabói* beds of Hungary (Hantken); in the later Tertiaries of Italy (d'Orbigny, Costa, Seguenza, &c.), and of the south-east of Spain (Parker and Jones); and in the Post-tertiary clays of Norway (Sars, Crosskey and Robertson) and elsewhere.

Uvigerina schwageri, n. sp. (Pl. LXXIV. figs. 8–10).

Test elongate, sub-ovate, tapering to a blunt point at the aboral end; segments numerous, only slightly inflated externally; surface ornamented by a few ill-defined, partial costæ; colour pure white. Length, $\frac{1}{16}$th inch (1·6 mm.).

It is impossible to convey fully by means of figures the very distinct appearance of this

finest of all the *Uvigerinæ*. The test is double the size of the typical *Uvigerina pygmæa*, and conspicuously white; the costæ are few and interrupted, and often so softened in outline as to be scarcely traceable. The young shell (fig. 10), which is of about the same size as a fully grown specimen of *Uvigerina pygmæa*, has the same general conformation as the adults (figs. 8, 9); from which it is clear that the latter are not mere overgrown examples of the typical species. I have much pleasure in associating the name of my friend Dr. Schwager of Munich with so striking a form.

The most characteristic specimens of *Uvigerina schwageri* have been obtained off Kandavu, Fiji Islands, at a depth of 210 fathoms, and at this locality it is very abundant. It also occurs off Raine Island, Torres Strait, 155 fathoms, and off the Philippines, 95 fathoms.

Uvigerina angulosa, Williamson (Pl. LXXIV. figs. 15–18).

Uvigerina angulosa, Williamson, 1858, Rec. For. Gt. Br., p. 67, pl. v. fig. 140.
„ *trigona*, Seguenza, 1862, Atti dell' Accad. Gioenia, vol. xviii. ser. 2, p. 123, pl. ii. figs. 1, 1*a*.
„ *pygmæa*, var. *angulosa*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 364, pl. xiii. fig. 68; pl. xvii. fig. 66.
„ *angulosa*, Seguenza, 1879, Atti dell' Accad. dei Lincei, ser. 3, vol. vi. p. 226, and p. 307.

Uvigerina angulosa is a small species, characterised primarily by its slender proportions and trifacial compression. The test is triangular in transverse section, and tapers towards both ends; the oral end finishes in a somewhat produced neck with phialine lip, the aboral extremity is generally obtuse or rounded. The surface is generally more or less costate.

This form was perhaps first observed by Parker and Jones, by whom it was treated as a trihedral variety of *Uvigerina pygmæa* (Ann. and Mag. Nat. Hist., 1857, ser. 2, vol. xix. p. 297); but whatever may be its genetic relationship there are few forms more easily distinguished. Its characters are fully stated by Williamson from recent British specimens.

Uvigerina angulosa is a widely distributed species. It is found in the North Atlantic, from the equator to lat. 65° or 70° N., at depths varying from two or three fathoms near the European coast-line, to 1630 fathoms in the open ocean. In the South Atlantic it has been observed at three Stations, with depths from 100 to 1025 fathoms; and it occurs at intervals in the Southern Ocean all the way from the Cape of Good Hope by Kerguelen Island to the Antarctic Ice-barrier. It has been met with in the Indian Ocean, at 900 fathoms and 1100 fathoms, and in the Mediterranean, from 90 fathoms to 250 fathoms; in the South Pacific at nine localities, from 8 fathoms to 1375 fathoms; and in the North Pacific at two, depth 50 to 150 and 400 fathoms respectively.

As a fossil it has been noticed in the Subapennine Clays of Italy (Parker and Jones,

Seguenza), in the Pliocene clay of the neighbourhood of Malaga (Parker and Jones), and in the Post-tertiary deposits of Norway (Sars, Crosskey and Robertson), and of the north-east of Ireland (Wright).

Uvigerina angulosa, var. *spinipes*, H. B. Brady (Pl. LXXIV. figs. 19, 20).

Uvigerina spinipes, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 64.

Test resembling that of *Uvigerina angulosa* in general contour, but not so distinctly triangular. Surface smooth, except near the aboral end, which is costate, and terminates in a number of short stout spines. Length, $\frac{1}{33}$rd inch (0·77 mm.).

Notwithstanding the very marked characters of some of the specimens, there seems to be little doubt that this form, originally described as a distinct species, is nothing more than a local variety of *Uvigerina angulosa*. Some of the shells are nearly cylindrical, or at most only slightly compressed on three sides, and they have a smooth exterior, except just at the initial end; but others are more or less angular.

The single recorded habitat is off Nightingale Island, Tristan d'Acunha, depth 100 to 150 fathoms.

Uvigerina porrecta, H. B. Brady (Pl. LXXIV. figs. 21–23).

Uvigerina porrecta, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 60, pl. viii. figs. 15, 16.

Test elongate, subspiral; early segments compactly arranged, obscurely triserial; later segments more or less distinct and interrupted, alternating irregularly. Peripheral edges of the chambers angular and projecting, more or less serrate; surface marked by irregular longitudinal costæ. Aperture situated in a produced tubular neck, usually without an everted lip. Length, $\frac{1}{50}$th inch (0·5 mm.).

This is a coral-reef species, and with one exception all the localities at which it has been found lie within the tropics. They are as follows:—off Bermuda, 435 fathoms; Port Louis, Mauritius, harbour-mud; at three points off the Fiji Islands, 12 fathoms, 210 fathoms, and 255 fathoms respectively; off Raine Island, Torres Strait, 155 fathoms; and in the North Pacific, north of Papua, 1850 fathoms.

Uvigerina brunnensis, Karrer (Pl. LXXV. figs. 4, 5).

Uvigerina brunnensis, Karrer, 1877, Geol. K. F.-J. Wasserleitung, p. 385, pl. xvi.*b*. fig. 49.

Under this name Dr. Karrer has described and figured a somewhat slender and elongate modification of the Uvigerine type, with granular or slightly hispid surface and

a few exceedingly delicate longitudinal striæ, chiefly near the primordial end of the test—very similar in all respects to the specimens represented by figs. 4 and 5.

Examples of this sort have been found living at two localities, namely :—off Christmas Harbour, Kerguelen Island, 120 fathoms, and on the western shores of Patagonia, 245 fathoms.

The specimens referred to by Karrer were Tertiary fossils from the "Mediterran-Stufe" of Berchtoldsdorf, near Vienna.

Uvigerina aculeata, d'Orbigny (Pl. LXXV. figs. 1, 2).

Uvigerina aculeata, d'Orbigny, 1846, For. Foss. Vien., p. 191, pl. xi. figs. 27, 28.

There is no true specific distinction between *Uvigerina aculeata*, d'Orbigny, and *Uvigerina asperula*, Czjzek; nevertheless it appears convenient to recognise both varieties, the one characterised by exostoses which take the form of stout spines or pointed perforated tubercles, either scattered over the whole test or over all except the very early chambers; the other rugose or hispid externally, the projecting points being minute and often arranged in lines.

Whether in the recent or fossil condition, spinous *Uvigerinæ* are much less common than those with merely hispid exterior. Such forms, however, have been met with at one locality in the South Atlantic, east of Buenos Ayres, depth 1900 fathoms; and at three in the South Pacific, namely,—north of Juan Fernandez, 1375 fathoms; off Ki Islands, 580 fathoms; and off Aru Island, 800 fathoms.

The specimens on which the original description was based were Miocene fossils from Nussdorf near Vienna.

Uvigerina asperula, Czjzek (Pl. LXXV. figs. 6–8).

Uvigerina asperula, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 146, pl. xiii. figs. 14, 15.
„ *orbigniana*, Id. Ibid. p. 147, pl. xiii. figs. 16, 17.
„ *gracilis*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 77, pl. v. fig. 39.
„ „ Bornemann, 1855, Ibid. vol. vii. p. 343, No. 1.
„ *hispida*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 249, pl. vii. fig. 95.
„ *asperula*, Seguenza, 1880, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 146, &c.

The Miocene fossils figured by Czjzek under the names *Uvigerina asperula* and *Uvigerina orbigniana* manifestly belong to the same species, and taken together the drawings represent very well the general characters of the hispid varieties of the genus. The outline of the test is ovate, varying as to relative length and breadth in different individuals; the apertural end is furnished with a long tubular neck, and the opposite extremity is either rounded or terminates in a stout spine. The exterior of the shell is rough and hispid; the minute aculei, being either distributed indiscriminately over

the surface, or set in more or less distinct rows. The final segment is sometimes nearly smooth externally.

Uvigerina asperula is a comparatively common species. Its geographical area extends from about lat. 56° N. in the North Atlantic, to considerably south of Kerguelen Island, lat. 52° S. in the Southern Ocean. The distribution-list includes five Stations in the North Atlantic, the depths ranging from 435 fathoms to 1675 fathoms; seven in the South Atlantic, 420 fathoms to 2350 fathoms; three in the Southern Ocean, 120 fathoms to 2600 fathoms; eighteen in the South Pacific, 37 fathoms to 2335 fathoms; and three in the North Pacific, 345 fathoms to 2300 fathoms.

Fossil specimens are recorded from the Miocene of Baden near Vienna (Czjzek), the Septaria-clay of Hermsdorf near Berlin (Reuss, Bornemann), the later Tertiaries of Calabria (Seguenza), and the Pliocene of Kar Nicobar (Schwager).

Uvigerina asperula, var. *auberiana*, d'Orbigny (Pl. LXXV. fig. 9).

Uvigerina auberiana, d'Orbigny, 1839, Foram. Cuba, p. 110, pl. ii. figs. 23, 24.

Under this name d'Orbigny has described a compressed variety of *Uvigerina* with rough or hispid exterior, the chambers of which are arranged, like those of *Textularia*, in two opposed alternating series. A shell of the same general form, but more closely beset with prickles, is represented in fig. 9.

Biserial specimens of similar character have been obtained from the North Atlantic, south of the Rockall Bank, 630 fathoms, and from the shore-sands of Cuba, Jamaica, and Martinique (d'Orbigny); also from two Stations in the South Pacific—off the Ki Islands, 580 fathoms, and off Kandavu, Fiji, 610 fathoms.

Uvigerina asperula, var. *ampullacea*, nov. (Pl. LXXV. figs. 10, 11).

The weaker modifications of *Uvigerina asperula* exhibit a tendency to a dimorphous habit of growth. The contour of such specimens is peculiar; the earlier segments form a broad, rounded, compact cluster, and to these are added one or two chambers joined end to end, and terminating in a produced tubular neck. In point of fact they constitute an intermediate group, connecting the hispid *Uvigerinæ* with certain forms of *Sagrina*. They cannot be separated specifically from *Uvigerina asperula*, but may be distinguished in a subordinate way by the varietal name "*ampullacea*."

The variety occurs in the North Atlantic to the south of Ireland, 725 fathoms, and off Culebra Island, West Indies, 390 fathoms; in the South Atlantic at three Stations, 350 fathoms to 675 fathoms; and in the South Pacific at four Stations, 410 fathoms to 620 fathoms. Thus it appears that the range of depth in nine localities lies between 350 and 725 fathoms.

Uvigerina interrupta, H. B. Brady (Pl. LXXV. figs. 12–14).

Uvigerina interrupta, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 60, pl. viii. figs. 17, 18.

Test much elongated, subspiral; composed of a number of inflated or subglobose segments of gradually increasing size, arranged around a long axis. Earlier segments combined so as to form a more or less compact spire; later segments disposed in an irregular, interrupted, alternating series, terminating in a tubular neck. Surface hispid or aculeate. Length, $\frac{1}{50}$th inch (0·5 mm.).

This variety bears very much the same relation to *Uvigerina asperula* that *Uvigerina porrecta* bears to the typical *Uvigerina pygmæa;* that is to say, it is an emaciated form, of which the extension in length is out of proportion to the number of chambers produced, and the continuity of the spiral series is more or less interrupted thereby.

Uvigerina interrupta has only been observed in dredgings from the South Pacific at the following points:—west coast of New Zealand, 150 fathoms; off Kandavu, Fiji, 210 fathoms and 255 fathoms; off Raine Island, Torres Strait, 155 fathoms; Humboldt Bay, Papua, 37 fathoms; and north of Juan Fernandez, 1375 fathoms.

Sagrina (d'Orbigny), Parker and Jones.

Sagrina[1] (d'Orbigny, 1839), emend. Parker and Jones [1865], Carpenter, Brady, Bütschli.
Sagraina, Reuss [1861], Zittel, Schwager, Marsson.
Dimorphina, Schwager [1866], Hantken.
Siphogenerina, Schlumberger [1883].

The generic term *Sagrina* was introduced by d'Orbigny for a biserial or Textulariform variety of *Uvigerina* with longitudinal costæ;[2] and the author subsequently assigned to the same genus a rough dimorphous Textularian, differing only from *Gaudryina* in possessing a terminal aperture.[3] Further investigation has shown that there is no direct relationship between these two species, and that in point of fact no new generic name was required for either. Under these circumstances it would have been well to have allowed the name to lapse; but it has been revived by Parker and Jones, and applied by them to a group of dimorphous *Uvigerinæ*, usually biserial in the arrangement of their early segments and Nodosariform in their later growth, and it is to this particular set of forms that the genus is now restricted.

The test of *Sagrina* presents every variety of contour, from the elongate oval of some of the typical *Uvigerinæ* to the cylindrical or moniliform shapes of the *Nodosariæ*. In

[1] The term *Sagrina* is retained as originally written. Changes in spelling such as that introduced by Reuss only tend to confuse the nomenclature, and require stronger justification than can be adduced in the present case.

[2] *Sagrina pulchella*, d'Orbigny, 1839, Foram. Cuba, p. 140, pl. i. figs. 23, 24.

[3] *Sagrina rugosa*, Id., 1840, Mém. Soc. géol. France, vol. iv. p. 47, pl. iv. figs. 31, 32.

well characterised specimens, the earlier portion of the shell consists of a few segments arranged either spirally, like *Uvigerina*, or in two alternating series as in *Textularia;* whilst the later portion is *Nodosaria*-like and composed of a number of chambers united in a straight or curved line. The aperture is a central rounded orifice, sometimes surrounded by a raised rim or border, but as frequently situated in a produced neck terminating in an everted phialine lip. The walls are invariably hyaline and perforate; and they present the same variety of surface-decoration as those of the typical *Uvigerinæ*. The genus is isomorphous with *Bigenerina* and *Clavulina*, from both of which it may be distinguished by the clear calcareous shell, and by the nature of the orifice.

There is little difficulty at any time in identifying typical specimens of the genus, that is to say, individuals of which the early spiral portion of the test is well developed; but when, as not unfrequently happens, the Uvigerine segments are abortive or are "straightened out," and the whole of the chambers constitute a single linear series, the result is a moniliform shell, which it is impossible to distinguish by any decisive characters from a *Nodosaria* (Pl. LXXVI. figs. 8–10). In such specimens the aperture, and the remains of the phialine lips of previous apertures still discernible near the base of some of the later segments, often afford the only indication of generic relationship. As already stated (p. 504), it is more than possible that the species figured under the name *Nodosaria abyssorum* (Pl. LXIII. figs. 8, 9) may eventually prove to be a deep-sea modification of the present type.

The genus *Sagrina* is common in the shallow water of tropical seas, affecting mostly depths of less than 200 fathoms, though it is occasionally found in much deeper areas. The geographical limit of its distribution extends as far north as the coast of Norway, and as far south as Kerguelen Island. It is rare in the fossil condition, and its occurrence appears to be confined to rocks of Miocene and Pliocene age.

Sagrina columellaris, H. B. Brady (Pl. LXXV. figs. 15–17).

Sagrina columellaris, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 64.
Siphogenerina glabra, Schlumberger, 1883, Feuille des Jeunes Naturalistes, ann. xiii. p. 25, pl. iii. fig. 1, 1*a*.

Test elongate, straight or only slightly curved, cylindrical, somewhat tapering; oral extremity broad and convex; aboral end more or less swollen, the extremity rounded or subangular. Uvigerine segments generally few in number, and distinct; uniserial segments numerous and short; sutural lines little if at all constricted externally. Aperture large, simple, with sessile phialine lip. Length, $\frac{1}{25}$th inch (1 mm.), sometimes more.

This species resembles *Sagrina dimorpha* in its cylindrical contour and smooth exterior, but it attains larger dimensions. The test is more tapering, the sutures are

flush, instead of being depressed and crenulated, and the walls are not conspicuously perforated. In some Australian specimens there is no perceptible swelling at the aboral end of the test, the Uvigerine portion being small and tapering to a blunt point. Schlumberger gives a sectional drawing of a shell of this species (*loc. cit.*), in which the Uvigerine necks of the earlier segments are long and tubular, each extending nearly to the top of the cavity of the succeeding chamber.

Sagrina columellaris has been collected off Gomera and off Palma, Canaries, at 600 fathoms and 1125 fathoms respectively; off the Azores, 450 fathoms; off Pernambuco, 350 fathoms; on the shore at Tamatavé, Madagascar; at three Stations on the south-east coast of Australia, 6 fathoms to 410 fathoms; and at five amongst the islands of the South Pacific, 125 to 620 fathoms.

Sagrina bifrons, H. B. Brady (Pl. LXXV. figs. 18–20).

Sagrina bifrons, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 64.

Test elongate, straight or only slightly curved, compressed; both sides somewhat concave along the median line; lateral edges thick and rounded Uvigerine segments few and distinct; those of the linear series numerous, short, and not inflated. Sutures flush externally; septa thickened by a deposit of clear shell-substance. Aperture large, oval; surrounded by a sessile lip. Length, $\frac{1}{30}$th inch (0·84 mm.).

This form is nearly allied to *Sagrina columellaris*, but may be distinguished by its short, stout, much compressed contour and thickened septa.

Sagrina bifrons has only been observed in one locality, the *Hyalonema*-ground, south of Japan, depth 345 fathoms.

Sagrina dimorpha, Parker and Jones (Pl. LXXVI. figs. 1–3).

Uvigerina (*Sagrina*) *dimorpha*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 420, pl. xviii. fig. 18.

The test of *Sagrina dimorpha* is nearly cylindrical, stoutly built, somewhat tapering, and rounded at both ends; the segments are short and but little inflated; the walls are thin and conspicuously perforated, and the aperture is a wide circular opening with a sessile lip or rim. The sutures are slightly excavated externally, and often, though not invariably, have a crenellated appearance, owing to the bridging over of the depression at regular intervals—a peculiarity well shown in fig. 1, and to a less degree in figs. 2, 3.

The geographical area inhabited by *Sagrina dimorpha* is wider than that of any other species of the same genus. It extends as far north as Bukken and Oster Fiords, near Bergen, Norway (Norman); and a single specimen from the Scottish coast is reported by

Mr. Robertson. It has been further noticed in the North Atlantic, off Gomera, Canaries, 620 fathoms ; and off Culebra Island, West Indies, 390 fathoms : in the South Atlantic, off Ascension, 420 fathoms ; and on the Abrolhos Bank, 260 fathoms (Parker and Jones), in the Red Sea, 580 fathoms ; in the Southern Ocean, off Prince Edward Island, 50 to 150 fathoms ; and in the South Pacific, off Tahiti, 420 fathoms and 620 fathoms ; off Ki Islands, 580 fathoms ; and off Kandavu, Fiji, 255 fathoms.

Sagrina virgula, H. B. Brady (Pl. LXXVI. figs. 4–10).

Sagrina virgula, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 61, pl. viii. figs. 19–21.
Nodosaria typus (?), Seguenza, 1880, Mem. R. Accad. dei Lincei, ser. 3, vol. vi. p. 136, pl. xiii. fig. 2.

Test linear, straight or slightly curved, cylindrical, tapering. Uvigerine segments few and minute, often entirely wanting; those of the linear series subglobular or ovate ; aperture usually wide, with an everted phialine lip ; surface in thin-shelled specimens hispid or setose. Length, $\frac{1}{50}$th to $\frac{1}{25}$th inch (0·5 to 1·0 mm.).

Perfect specimens of this species in the normal condition (figs. 4–6) are easily distinguished from any of their congeners by their inflated or subglobular chambers. The earlier segments are minute, whether combined in straight or spiral series ; and in the latter case they form collectively a very small proportion of the entire shell. Frequently the Uvigerine segments are wanting ; and it is almost impossible to name any positive characters by which shells so constructed (figs. 8–10) can be separated with certainty from true Nodosarians. The large aperture and spreading phialine lip generally serve to indicate their affinity, and sometimes traces of the everted neck are evident in the form of a rim or the remains of a row of spines on the inferior or aboral face of the chambers ; but in the absence of such marks, the relationship of individual specimens can only be determined by the company in which they are found.

Sagrina virgula has been obtained in the South Atlantic, off Pernambuco, 675 fathoms: with that exception the distribution, which extends altogether to ten localities, is confined to the South Pacific, the bathymetrical range being from 12 fathoms to 2075 fathoms. The specimens from deep water are thick-shelled as compared with those from coral-sands.

Sagrina nodosa, Parker and Jones (Pl. CXIV. fig. 18, *a.b.*).

Uvigerina (*Sagrina*) *nodosa*, Parker and Jones (non d'Orbigny), 1865, Phil. Trans., vol. clv. p. 363, pl. xviii. fig. 15.

Messrs. Parker and Jones (*loc. cit.*) have referred this particular modification of the type to the *Uvigerina nodosa* of d'Orbigny, a species based upon a number of figures

in Soldani's Testaceographia.[1] As has been shown elsewhere, the name in its original application was needless, "the five figures" referred to by d'Orbigny being "all *Uvigerina pygmæa*, not differing more amongst themselves than may be seen in any batch of recent specimens;"[2] there is, therefore, no reason why it should not be retained for the particular form described by the English authors.

Sagrina nodosa furnishes the morphological links connecting *Sagrina striata*, Schwager, with the typical *Uvigerinæ*. The test is proportionately stouter and the Uvigerine section is relatively larger than in Schwager's species, and the chambers of the uniserial portion are less inflated and more compactly fitted. The drawing (Pl. CXIV. fig. 18) represents a specimen with fewer Uvigerine segments than the test usually possesses, whilst in Parker and Jones's illustration, on the other hand, almost the entire shell is spirally arranged, and there are only two uniserial chambers. Between these extremes every variety of conformation is to be found.

Sagrina nodosa is by no means a common form: so far as the Challenger collections are concerned, it only appears at one locality,—off the Cape of Good Hope, depth 150 fathoms. Otherwise it has been reported from the Mediterranean and from the Italian Tertiaries.

Sagrina striata, Schwager (Pl. LXXV. figs. 25, 26).

Dimorphina striata, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 251, pl. vii. fig. 99.
„ *elegans*, Hantken, 1875, Mitth. Jahrb. d. k. ung. Anstalt, vol. iv. p. 63, pl. vii. fig. 9.
Sagraina striata, Schwager, 1877, Tav. Sistem. dei Foram., fig. 35.

This species differs from the allied *Sagrina raphanus* in the subglobular form of the segments and the superficial ornament of delicate, raised, longitudinal lines. The illustration (fig. 25) represents an average example of the species as found in the living condition. I have never met with recent specimens exhibiting the beautiful symmetry of contour and regularity of striation shown in the original drawing, though the salient morphological characters correspond pretty closely in other ways.

Dr. Schwager draws attention to the general similarity of his specimens to the *Nodosaria striatissima* of Stache (Novara-Exped., geol. Theil, vol. i. pt. 2, p. 198, pl. xxii. fig. 25, *a–f*); and, after careful examination of the drawings of the latter form, I have little doubt that most if not the whole of the fossils figured under that name belong in reality to the present species, notwithstanding the apparent absence of Uvigerine initial segments.

Sagrina striata has been obtained as follows:—off the coast of South America, south

[1] *Uvigerina nodosa*, d'Orbigny, 1826, *Ann. Sci. Nat.*, vol. vii. p. 269, No. 3;—Testaceographia, vol. i. pt. 2, p. 118, pl. cxxvi. figs. *xx*, *yy*, *zz*, *A*, *B*.

[2] Parker, Jones, and Brady, *Ann. and Mag. Nat. Hist.*, ser. 4, vol. viii. p. 171, No. 67.

of Pernambuco, 350 fathoms; shore-sand, east coast of Madagascar; off Kandavu, Fiji Islands, 210 fathoms; off New Hebrides, 125 fathoms; Torres Strait, 3 to 11 fathoms; off Ki Islands, 129 fathoms; and off the Philippines, 95 fathoms.

Dr. Schwager's specimens were from the Pliocene marl of Kar Nicobar; and von Hantken's *Dimorphina elegans*, which appears to be the same species, from the lower *Clavulina*-beds of Ofen, Hungary. I have also good examples from the Miocene deposits of Malta.

Sagrina raphanus, Parker and Jones (Pl. LXXV. figs. 21–24).

Uvigerina (*Sagrina*) *raphanus*, Parker and Jones, 1865, Phil Trans., vol. clv. p. 364, pl. xviii. figs. 16, 17.

Siphogenerina costata, Schlumberger, 1883, Feuille des Jeunes Naturalistes, ann. xiii. p. 26, woodcut fig. B.

The *Sagrina raphanus* of Parker and Jones is represented by a stout cylindrical shell with rounded extremities, and with a few well-marked, parallel, longitudinal costæ by way of surface-decoration—very similar in all respects to the specimens portrayed in figs. 21, 22. Shells of somewhat different contour, broad near the oral end and tapering to a point at the opposite extremity (figs. 23, 24), are frequently met with, and such specimens often attain comparatively large dimensions; but their peculiarities appear to be the result of individual deviations from the typical mode of growth, and afford no ground for even varietal distinction.

Sagrina raphanus is essentially a coral-reef Foraminifer. The following list of the localities at which it has been collected furnishes a general outline of its area of distribution:—shore-sands, Bermuda, West Indies, Panama, and Madagascar; anchor-mud, Port Louis, Mauritius; dredged sands, off Calpentyn, Ceylon, 2 fathoms, off Kerguelen Island, 12 fathoms, off the Philippines, 95 fathoms, off Honolulu, Sandwich Islands, 40 fathoms; and at fifteen Stations amongst the islands of the South Pacific, at depths ranging from 2 fathoms to 260 fathoms.

Sagrina (?) *tessellata*, n. sp. (Pl. LXXVI. figs. 17–19).

Test cylindrical, arcuate, slightly tapering; composed of a few (four or five) elongate, oval or subcylindrical segments, each a good deal larger than its predecessor, joined end to end. Surface areolated; the areæ, which are of elongate hexagonal form, disposed in regular, alternating, transverse lines. Aperture a central rounded orifice, with or without a sessile lip. Length, $\frac{1}{45}$th inch (0·57 mm.).

The foregoing provisional description is based upon two or three specimens of an exceedingly obscure organism, found in dredged sands from Nares Harbour, Admiralty Islands, 17 fathoms, and Raine Island, Torres Strait, 155 fathoms. The general appear-

ance of the shell is that of *Sagrina* rather than of *Nodosaria;* and in both the localities named the former genus abounds. For these reasons, rather than upon any direct or positive evidence, the species has been placed temporarily in its present position.

Sagrina (?) *annulata*, n. sp. (Pl. LXXVI. figs. 20, 21).

Test subcylindrical; oral end rounded, aboral extremity obtusely angular or rounded; composed of few (two to four), elongate, somewhat inflated segments, united end to end. Surface marked by closely set, slightly depressed, transverse lines. Aperture a simple terminal rounded orifice. Length, $\frac{1}{35}$th inch (0·75 mm.).

Pending the discovery of further specimens, the above characters may serve to distinguish an obscure species, of which only two or three individuals have been met with during the examination of the Challenger material. It is quite possible that the organism may not belong to the genus *Sagrina*.

The specimens referred to were found amongst coral débris from the Honolulu Reefs, 40 fathoms, and in sand dredged off the Azores, 450 fathoms.

Sagrina limbata, n. sp. (Pl. CXIII. fig. 14).

Test elongate, subcylindrical, compressed, tapering, somewhat twisted or otherwise irregular. Uvigerine portion relatively very small; oral end rounded, aboral extremity angular or pointed; segments numerous. Surface marked by a number of raised transverse bands of shell-substance (concealing the sutures) connected by a similar band on the median line on either side of the test. Aperture terminal, consisting of a large oval orifice with raised border. Length, $\frac{1}{60}$th inch (0·42 mm.).

This is a minute species, the precise structure of which has not as yet been satisfactorily determined; and, as a comparatively small number of specimens only have been found, the foregoing characters are provisional and incomplete. As a general rule the limbation of a foraminiferal shell follows the course of the sutural lines, but in the present instance it appears as though the central band was deposited in a hollow on either face of the test, like that which is seen in some specimens of *Sagrina bifrons*, and that it assumes to a certain extent the character of mere exogenous ornament. This variety is apparently closely related to *Sagrina annulata*.

Sagrina limbata has only been encountered at a single locality,—off Raine Island, Torres Strait, depth 155 fathoms.

Sub-family 4. Ramulininæ.

Ramulina, Rupert Jones.

Ramulina, Jones [1875], Wright, Brady.

Test free, branching; consisting of a calcareous tube, swollen at intervals so as to form more or less definite, often irregular segments, from which lateral stolons or branches are given off. Texture hyaline.

In Mr. Wright's List of the Cretaceous Microzoa of the North of Ireland,[1] figures are given of two obscure organisms, under the names *Ramulina lævis* and *Ramulina brachiata* respectively. The specimens represented are manifestly only fragments, and neither generic nor specific descriptions are furnished beyond the general statement that the former (*Ramulina lævis*) is a "simple, calcareous, subsegmented, branching, Nodosarian form." An opinion is further expressed, on the authority of Prof. Rupert Jones, that "the so-called *Dentalina* (?) *aculeata* of d'Orbigny" should be transferred to the same genus.

Those who have devoted much attention to the microzoa of the Chalk must be quite familiar with the organisms referred to, though in the fragmentary condition in which they are commonly found they may not have been recognised as Foraminifera. There can, however, be no doubt of their close affinity to certain forms, still living at moderate depths in the seas of tropical and subtropical latitudes, to which the name *Ramulina globulifera* has been assigned. As to the *Dentalina aculeata* of d'Orbigny, the original description and figures,[2] so far as I am able to judge, appear to refer to a common, hispid, Dentaline *Nodosaria*.

Ramulina globulifera, H. B. Brady (Pl. LXXVI. figs. 22–28).

Ramulina globulifera, Brady, 1869, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 58, pl. viii. figs. 32, 33.

Test free, branching; composed of segments of different sizes connected by stoloniferous tubes of diverse lengths. Segments from two to eight, or even more, in number; globular or subglobular; each provided with numerous tubulated apertures, radiating from different portions of the periphery, some of which terminate in fresh chambers. Stoloniferous tubes narrow in proportion to the bulk of the segments, circular in section. Texture hyaline; surface hispid or aculeate. Length of complete specimens $\frac{1}{15}$th inch (1·7 mm.) or more.

[1] *Report and Proc. Belfast Nat. Field Club*, 1873–4, Appendix, p. 88, pl. iii. figs. 19, 20.

[2] *Mém. Soc. géol. France*, 1840, vol. iv. p. 13, pl. i. figs. 2, 3.

The foregoing characters apply to typical examples of the species, but irregular or anomalous specimens are not uncommon. In some of the latter the chambers are misshapen, in others the stoloniferous tubes are twisted or of uneven diameter, or at times abortive. Fragments have also been found of which the original shell appears to have consisted of reticulating tubes without distinct chambers. The species is probably very nearly related to the Cretaceous forms already referred to, possibly identical with them; but it is difficult to speak with any degree of certainty in the absence of good representative specimens. Even in the recent condition approximately complete shells are very rarely met with, whilst those obtained from fossiliferous deposits are almost invariably little more than disjointed segments.

Ramulina globulifera has been observed at three Stations in the North Atlantic, namely—off Gomera, Canaries, 620 fathoms; off Sombrero Island, West Indies, 450 fathoms; and off Bermuda, 435 fathoms; and at one point in the North Pacific, off the Philippines, 95 fathoms. The remaining six localities are in the South Pacific,—off the west coast of New Zealand, 145 and 275 fathoms; near the Fiji Islands, 210 and 255 fathoms; and amongst the islands south of New Guinea, 129 and 155 fathoms. Fragments apparently belonging to this or some allied variety of *Ramulina*, have been found on the Atlantic shores of Ireland, by Mr. F. W. Millett.

Family VIII. GLOBIGERINIDÆ.

The Family Globigerinidæ, as now proposed, corresponds in the main with the Sub-family Globigerinæ of Carpenter, Parker, and Jones; but for reasons which will be stated on a subsequent page, the genus *Carpenteria*, which has hitherto been included in the group, is omitted, and the genera *Hastigerina* and *Candeina*, the characters of which were imperfectly understood when the "Introduction" was written, occupy its place in the series. Although the Family, as a whole, does not present that unbroken succession of minute modifications which has been remarked in some other groups of similar extent, the salient features of the more important types are sufficiently alike to indicate close natural affinity, and their relationship is further attested by the similarity of the conditions under which they live.

The morphological characters of the Family are too varied to be capable of brief definition, and they can only be stated in broad and general terms. The test is always of the most simple construction, composed of few chambers, usually much inflated, or at least convex externally, and spirally arranged; the walls are distinctly perforated, and there is no trace of supplementary skeleton or interseptal canals. The aperture assumes very diverse forms, not only in the different genera, but sometimes in the different species of the same genus. In the typical Globigerine shell each individual chamber opens into a deep central depression or cavity on the inferior side; but in the nautiloid varieties of

Globigerina, as well as in those of *Pullenia*, and also in the genus *Hastigerina*, the aperture is a broad curved fissure, symmetrically placed at the inner margin of the segments. In some turbinoid species the aperture is single, and only differs from that of the *Rotalinæ* in its relatively large size; in others it is divided, and takes the form of a number of smaller orifices, part of which are situated on the superior face of the test; whilst in *Orbulina*, there is no general orifice in the ordinary sense of the term, its place being supplied by a set of abnormally large perforations.

As already stated, the constituent genera of the Globigerinidæ do not arrange themselves in a continuous series like those of the Miliolidæ or the Lagenidæ, but form several collateral groups, of which the corresponding modifications exhibit to a limited degree the sort of isomorphism that is so conspicuous a feature of the Rotalidæ. Thus *Globigerina bulloides* finds an isomorph in *Candeina nitida*; *Globigerina conglobata*, *Sphæroidina bulloides*, and *Pullenia obliquiloculata* are in like manner parallel modifications of their respective types; as are also *Globigerina æquilateralis*, *Hastigerina pelagica*, and *Pullenia quinqueloba*. In connection with this subject it is of interest to note that similar isomorphisms may be traced between the *Globigerinæ* and the *Rotalinæ*, though the number of corresponding forms is relatively small.

The most noteworthy characteristic of the Globigerinidæ as a Family is the pelagic habit of most of the species. Certain genera, like *Hastigerina*, are exclusively pelagic; and of others a great majority of the known varieties have been found in the free-swimming condition. Even *Pullenia* and *Sphæroidina*, of which the reputed typical species have only hitherto been met with in bottom-dredgings, have well-marked pelagic representatives.

Globigerina, d'Orbigny.

Globigerina, d'Orbigny [1826], Roemer, Reuss, Bailey, Ehrenberg, Costa, Parker and Jones, Egger, Williamson, Pourtales, Karrer, Carpenter, Wallich, Brady, Owen, Schwager, &c.
Rosalina, pars, d'Orbigny [1839], Ehrenberg, Reuss, Rupert Jones.
Rotalia, pars, Ehrenberg [1854], Kübler and Zwingli.
Phanerostomum, pars; *Ptygostomum*, pars; *Planulina*, pars, Ehrenberg [1854].
Rhynchospira, Ehrenberg (?), Reuss, MS., Karrer [1877].
Pylodexia, Ehrenberg [1859].
Rotalina, pars, Seguenza [1862].
Aristerospira, pars, Ehrenberg [1873].

The distinctive characters of the genus *Globigerina* are stated by d'Orbigny in the "Tableau Méthodique" in the following terms:—"Test libre, trochoïde, irrégulier; spire confuse, formée par des loges sphériques plus ou moins distinctes; ouverture en forme d'échancrure plus ou moins profonde, située vers l'axe de la spire à l'angle ombilical."[1] The genus is described at considerable length by Dr. Carpenter and his colleagues in the

[1] *Ann. Sci. Nat.*, 1826, vol. vii. p. 277.

Introduction to the Study of the Foraminifera ;[1] and more briefly, but in the same sense, by Parker and Jones in their memoir on Foraminifera from the North Atlantic and Arctic Ocean, as follows :—"The shell of *Globigerina* is composed of a series of hyaline and perforated chambers, of a spheroidal form, arranged in a spiral manner, and each opening by a large aperture around the umbilicus, in such a manner that the apertures of all the chambers are apparent on that aspect of the shell, and form a large 'umbilical vestibule.'"[2] This umbilical vestibule, into which "each segment opens by a large crescentic orifice, the several chambers having no direct communication with each other," is a feature of some prominence in Carpenter's description.

Parker and Jones, in their paper above quoted, record the occurrence of only two species of *Globigerina*, namely, the typical *Globigerina bulloides* and *Globigerina inflata;* and in their supplementary tables recognise but two others, *Globigerina helicina* and *Globigerina hirsuta*. The allusions in Dr. Carpenter's work are confined to the same forms. This paucity of illustration must be attributed to the fact that the researches of the authors referred to were based chiefly upon the northern representatives of the type ; and the limited view which they adopt as to the generic characters of the group results more or less from the same circumstance.

Owing to the wide area embraced by the dredging operations and the diverse conditions under which the tow-net was employed, the Challenger collections have opened a new field for the investigation of the genus ; and its morphological characters have been found to present a far wider range of variability than seems to have been previously suspected.

With rare exceptions, which need not at present be taken into account, the test of *Globigerina* is always distinctly spiral. In the typical *Globigerina bulloides* and its immediate allies it is constructed on the Rotaline plan, that is to say, the whole of the segments are visible on the superior face of the shell, those of the last convolution only on the inferior ; but in certain forms, of which *Globigerina æquilateralis* is the most important, the arrangement is planospiral, and the segments are seen equally on both faces of the test. The general external contour of the shell is either conical, trochoid, turbinoid, subglobular, nautiloid, plano-convex, compressed and carinate, or complanate.

The number of segments of which the adult shell is composed, varies in different species from three to about twenty, and they are arranged so as to form from one to three convolutions. The individual chambers are typically spherical, and they are separated externally by deep depressions ; but in the compact varieties of the genus they are not more convex externally than those of other Rotaliform Foraminifera. In certain cases part of the segments of the outer convolution are elongated radially and have pointed extremities, whilst in others the chambers are compressed and their sutures occasionally limbate.

[1] Introd. Foram., p. 181.

[2] *Phil. Trans.*, 1865, vol. clv. p. 365.

During the very early stages of growth the shell-wall is thin and transparent, and smooth externally; but in a considerable proportion of pelagic specimens the surface of the test is more or less beset with needle-like spines, even before the shell is fully grown. The spinous character is not peculiar to any one species, but, on the contrary, examples of every form hitherto found in surface-water have been observed at one time or other in the hirsute condition. The length and substance of the spines vary greatly in different surface-gatherings, and there are nearly always present a considerable number of non-spinous shells. The *Globigerinæ* found in bottom-dredgings are rarely spinous, except when they happen to have been obtained from the thin top layer of the deposit. The spines are too delicate to bear the least attrition, and they are speedily broken or worn down by contact with other organisms. As the shell thickens it becomes areolated externally by cup-shaped depressions being left around the perforations. This also is a generic rather than a specific character, though more noticeable in some forms than in others. In worn specimens the surface is often only rough or granular.

The substance of the shell increases with age; and in some cases the walls attain a thickness of $\frac{1}{250}$th inch (0·1 mm.) or more, equal to about one-eighth of the longer diameter of the test. The shell is always conspicuously perforated, but the size of the pore-canals differs in the various species, ranging from a diameter of $\frac{1}{10,000}$th inch (0·0025 mm.) in *Globigerina pachyderma* to $\frac{1}{3000}$th or $\frac{1}{2500}$th inch (0·0084 or 0·01 mm.) in *Globigerina sacculifera* and *Globigerina conglobata*.

The typical aperture, a description of which has been already quoted, consists of the orifices of the individual segments opening directly into a deep umbilical recess; but this is only exemplified in *Globigerina bulloides* and its immediate allies. In another group of forms the external aperture is a single lunate or arched orifice at the inferior umbilical margin of the final segment; in a third series the single inferior orifice is supplemented by a number of rounded openings on the superior face; whilst in the planospiral varieties the aperture is symmetrically placed at the inner margin of the terminal segment, or, when the convolutions are loose and not in immediate contact, the orifices of the individual chambers are left unenclosed and the condition approaches that of the type.

On the basis of the characters which have been enumerated the genus may be divided into a number of more or less well-marked groups, which, though they have no claim to rank as true species, have features sufficiently persistent for easy definition. These different sub-species, or varieties, or whatever they may be called, vary in zoological value. In some the characters exhibit as much constancy as is usually found amongst the Foraminiferal species, whilst others represent only the salient points of an easily-traced gradational series. The arrangement of the following scheme is to a certain extent artificial, but on the whole it presents a natural and easily comprehended view of the genus.

Scheme of the Genus GLOBIGERINA.

A. Test Rotaliform, chambers' opening individually into an inferior umbilical vestibule.

1. Segments globular, about seven in number, four in the outer whorl, *Gl. bulloides*, d'Orb.
2. Three segments in the outer whorl, relatively very large, . ,, ,, var. *triloba*, Reuss.
3. Shell turbinoid, orbicular, somewhat compressed; segments numerous, inflated, five or six in the outer whorl, . . *Gl. dubia*, Egger.
4. Shell much compressed, outspread; with about three distinct convolutions; segments five or more in the outer whorl, . *Gl. cretacea*, d'Orb.
5. Shell biconvex, much compressed; periphery thin or subcarinate; segments numerous, marginate, ... *Gl. marginata*, Reuss, sp.
6. Shell compressed or complanate; periphery thick, square, or bicarinate; segments numerous, arranged in about three whorls; sutures limbate, ... *Gl. linnæana*, d'Orb., sp.
7. Shell trochoid; early segments small and regular, later segments, especially the final one, much elongated, and spreading radially, *Gl. digitata*, Brady.

B. Test Rotaliform, external aperture a single arched opening at the inferior umbilical margin of the final segment.

8. Shell small, subglobular, somewhat compressed; consisting of two convolutions, the outermost composed of four segments; segmentation obscure externally, ... *Gl. pachyderma*, Ehrenb., sp.
9. Shell rounded, both faces convex; consisting of about three convolutions, the outermost having five segments; later segments inflated; aperture semicircular, comparatively small, . . *Gl. dutertrei*, d'Orb.
10. Superior face nearly flat, inferior highly convex, peripheral edge rounded; four segments in the outer whorl; aperture large and gaping, ... *Gl. inflata*, d'Orb.

C. Test Rotaliform; aperture a single arched orifice on the inferior face, and two, three, or more rounded openings in the sutural depressions of the superior face.

11. Shell forming a regular, more or less elevated, trochoid spire; three segments in the final convolution; colour pink, . *Gl. rubra*, d'Orb.
12. Shell nearly spherical, compact; the three segments of the final whorl large and inflated, forming a convex base, . . *Gl. conglobata*, Brady.
13. Shell oblong, compressed; segments few, four in the outer convolution; ultimate segment, and sometimes the penultimate, elongated radially and more or less pointed, . . . *Gl. sacculifera*, Brady.
14. Shell oblong, ovate; the outer whorl consisting of four segments, two large and oblong, side by side, two small and rounded placed one at each end, ... *Gl. helicina*, d'Orb.

D. Test planospiral, bilaterally symmetrical, aperture on the median line.

15. Test evolute, loosely coiled, aperture symmetrically placed at the inner margin of each segment, ... *Gl. æquilateralis*, Brady.

With reference to *Globigerina digitata*, it may be remarked that large examples have a tendency to assume the planospiral mode of growth, the outer convolution almost enclos-

ing the earlier chambers. When this is the case the aperture takes a similar form and position to that of *Globigerina æquilateralis*.

The abnormal and irregular specimens classed by Reuss under the generic or sub-generic term *Rhynchospira*,[1] examples of which are portrayed in Pl. LXXXI. figs. 6, 7, have not been included in the foregoing summary. Such shells are comparatively rare. They consist of acervuline masses of Globigerine chambers arranged without apparent order; and to all appearance they are nothing more than monstrous or wild-growing individuals, though it is difficult to say to which precise variety they are referrible.

Of the species enumerated, all the more important, except *Globigerina pachyderma*, have been found living at the surface of the sea. Some doubt attaches to the occurrence of *Globigerina cretacea* in the recent condition; and *Globigerina digitata*, *Globigerina helicina*, and *Globigerina linnæana* are, under any circumstances, exceedingly rare in comparison with most of the other recent forms. Apart from these, which scarcely affect a general statement, the whole series pertains to the pelagic fauna of mid-ocean.

The geographical distribution of the genus is world-wide. At every latitude, indeed in almost every sea in which the tow-net and the sounding-line have been employed, *Globigerinæ* have been brought to light; and over large areas they exist in a profusion far outweighing in the aggregate all other organisms whatsoever. So far as is known, the earliest appearance of the type is in certain calcareous rocks of Jurassic age, in Switzerland (Haeusler)[2], but it was neither common nor widely diffused until the latter half of the Cretaceous period. It is represented in the Gault, and abundantly in the Chalk, and reappears at every stage of the Tertiary epoch.

Globigerina bulloides, d'Orbigny (Pls. LXXVII., LXXIX. figs. 3–7).

"Polymorpha *Tuberosa* et *Globulifera*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 117, pl. cxxiii. figs. *H. I. O. P.*

"Testæ *tuberosæ*," &c., Id., 1798, Ibid., vol. ii. p. 20, pl. vi. figs. *dd.*, *ee.*

Globigerina bulloides, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 277, No. 1.—Modèles, No. 17 (young), and No. 76.

„ „ Id. 1839, Foram. Amér. Mérid., p. 37.

„ „ Id. 1839, Foram. Canaries, p. 132, pl. ii. figs. 1–3, 28.

„ *hirsuta*, Id. Ibid. p. 133, pl. ii. figs. 4–6.

„ *siphonifera*, Id. 1839, Foram Cuba, p. 95, pl. iv. figs. 15–18.

„ *bulloides*, Id. 1846, For. Foss. Vien., p. 163, pl. ix. figs. 4–6.

„ *concinna*, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 373, pl. xlvii. fig. 8.

„ *diplostoma*, Id. Ibid. p. 373, pl. xlvii. figs. 9, 10.

„ *depressa*, Ehrenberg, 1854, Mikrogeologie, pl. xix. fig. 92.

„ *foveolata* (pars), Id. Ibid. pl. xxii. fig. 74.

[1] A manuscript name, said to have originated with Ehrenberg; employed by Karrer, on the authority of Reuss, for one of these wild-growing forms, *Globigerina* [*Rhynchospira*] *glomerata*, (Geol. d. K. F.-J. Wasserleitung, p. 387, pl. xvi. *b.*, fig. 53).

[2] Reuss mentions a fossil resembling *Globigerina triloba*, from the Trias of St. Cassian, but with doubt apparently as to its real affinity.—*Sitzungsb. d. k. Ak. Wiss. Wien*, 1868, vol. lvii. p. 105.

Globigerina cretæ, Ehrenberg, 1854, Mikrogeologie, pl. xxvi. fig. 44;—pl. xxx. fig. 38.
„ *stellata*, Id. Ibid. pl. xxvi. fig. 45.
„ *ternata*, Id. Ibid. pl. xxxv. B, figs. 5, 6.
Planulina porotetras, Id. Ibid. pl. xx. II. fig. 16.
„ *pertusa*, Id. Ibid. pl. xxii. fig. 75.
„ *stigma*, Id. Ibid. pl. xxv. fig. 29.
Rotalia rudis, Id. Ibid. pl. xxiv. figs. 35, 36.
„ *leptospira*, Id. Ibid. pl. xxiv. fig. 39.
„ *senaria* (pars), Id. Ibid. pl. xxiv. fig. 40.
Ptygostomum orphei, Id. Ibid. pl. xxxv. B, figs. 1, 2.
Phanerostomum atlanticum, Id. Ibid. pl. xxxv. B, figs. 3, 4.
Globigerina bulloides, Kübler and Zwingli, 1866, Neujahrsblatt v. d. Bürgerbib. in Winterthur, pt. 2, p. 22, pl. iii. figs. 30, 31.
„ *taminensis*, Id. Ibid. p. 24, pl. iii. fig. 26.
„ *bulloides*, Gümbel, 1868, Abh. d. k. bayer. Akad. d. Wiss., II. Cl., vol. x. p. 661, pl. ii. fig. 106.
„ *alpigena* (?) Id. Ibid. p. 661, pl. ii. fig. 107.
„ *eocœna*, Id. Ibid. p. 662, pl. ii. fig. 109.
Planulina mauryana, Ehrenberg, 1873, Abhandl. d. k. Akad. Wiss. Berlin (1872), p. 388, pl. iii. fig. 1.
„ *globigerina*, Id. Ibid. p. 388, pl. iii. fig. 3.
„ *megalopentas*, Id. Ibid. p. 388, pl. iv. fig. 7.
Pylodexia platytetras, Id. Ibid. p. 388, pl. iii. fig. 14.
Aristerospira omphalotetras, Id. Ibid. p. 388, pl. iii. fig. 15.
Globigerina detrita, Terquem, 1875, Anim. sur la Plage de Dunkerque, fasc. i. p. 31, pl. iv. fig. 4, *a–c*.
„ *bulloides*, Id. Ibid. p. 31, pl. iv. fig. 5, *a*, *b*.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 71.

Test spiral, subtrochoid; superior face convex, inferior more or less convex but with deeply sunken umbilicus, periphery rounded, lobulated; adult specimens composed of about seven globose segments, of which four form the outer convolution; the apertures of the individual chambers opening independently into the umbilical vestibule. Diameter, sometimes $\frac{1}{40}$th inch (0·63 mm.), but oftener much less.

The typical *Globigerina bulloides* was described by d'Orbigny on four or five different occasions, in terms which, though not precisely identical, agree in all important particulars; and his Model, No. 76, is an excellent illustration of the characters indicated by the descriptions. The species is now too well known to require extended notice. It is the commonest of all the Globigerine forms, not only throughout the temperate zones, where it exists in enormous abundance, but also in areas over which other varieties are similarly plentiful. The morphological characters are tolerably uniform, but under different external conditions the specimens exhibit considerable diversity in point of size. For example, the drawings, Pl. LXXIX. figs. 6 and 7, both represent fully-grown shells, with about the same number of segments, equally magnified. Both are bottom specimens, fig. 6 being an average example from the British coast, whilst fig. 7 is one from mid-ocean.

Globigerina bulloides is a cosmopolitan species. It occurs in surface-gatherings wherever Foraminifera have been collected, and in bottom-dredgings at almost every latitude.

The earliest appearance of the species is in the Cretaceous period, and it has been found in the marine deposits of each succeeding stage of the geological series.

Globigerina bulloides, var. *triloba*, Reuss (Pl. LXXIX. figs. 1, 2; Pl. LXXXI. figs. 2, 3).

Globigerina triloba, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 374, pl. xlvii. fig. 11, *a–e*.
Pylodexia atlantica, Ehrenberg, 1873, Abhandl. d. k. Akad. Wiss. Berlin (1872), p. 388, pl. iv. fig. 2.

General characters similar to those of *Globigerina bulloides*, but with the final convolution consisting of three relatively very large segments which sometimes form the entire visible shell.

This is a comparatively unimportant subvarietal form, but it is one which has been generally recognised by Continental palæontologists.

In distribution it is always associated with the typical *Globigerina bulloides*.

Globigerina dubia, Egger (Pl. LXXIX. fig. 17, *a.b.c.*).

Globigerina dubia, Egger, 1857, Neues Jahrb. für Min., &c., p. 281, pl. ix. figs. 7–9.
„ *conglomerata* (?), Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 255, pl. vii. fig. 113.
„ *dubia*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 71.

Test rotaliform, subglobular, somewhat compressed; margin rounded and lobulated; inferior umbilicus large and deeply sunk; composed of about three convolutions, the outermost of which consists of five or six relatively small, inflated segments; the apertures of the chambers opening directly into the umbilical vestibule. Diameter often nearly $\frac{1}{35}$th inch (0·73 mm.).

The *Globigerina dubia* of Egger can only be accepted as a varietal modification of *Globigerina bulloides*, representing perhaps the best development of the typical characters. The test attains somewhat large dimensions, it is stout and compactly built, distinctly Rotalian in general conformation, and with a well-marked umbilical cavity. It has frequently as many as fourteen or fifteen segments.

Pelagic specimens of this variety have been taken in the South Atlantic and in the North and South Pacific; and in bottom-ooze it has been found also in the North Atlantic. Its northern limit appears to be about lat. 56° N., a little to the south of

the Rockall Bank; whilst in the opposite hemisphere it reaches as far as about lat. 46° S. in the Southern Ocean.

The specimens originally described by Egger were fossils from the Miocene of Lower Bavaria. Examples of *Globigerina conglomerata* from the Pliocene of Kar Nicobar, for which I am indebted to Dr. Schwager, present characters almost identical with those of many of the recent shells, though sometimes showing an approach towards the general form of *Globigerina conglobata*. The author's figure (*loc. cit.*), is not a very satisfactory rendering of their distinctive characters.

Globigerina cretacea, d'Orbigny (Pl. LXXXII. fig. 10, *a–c* [?]. Fossil specimen, fig. 11, *a–c*.).

Globigerina cretacea, d'Orbigny, 1840, Mém. Soc. géol France, vol. iv. p. 34, pl. iii. figs. 12–14.
„ *foveolata* (pars), Ehrenberg, 1854, Mikrogeologie, pl. xxiv. fig. 49.

„ *libani*,	Id.	Ibid.	pl. xxv. fig. 30.
Planulina pachyderma,	Id.	Ibid.	pl. xxv. fig. 31.
Rotalia pertusa,	Id.	Ibid.	pl. xxiv. fig. 41.
„ *aspera*,	Id.	Ibid.	pl. xxvii. figs. 57, 58;—pl. xxviii. fig. 42;—pl. xxxi. fig. 44.
„ *globulosa*,	Id.	Ibid.	pl. xxvii. fig. 60;—pl. xxviii. figs. 40, 41; pl. xxxi. figs. 40, 41, 43.
„ *densa*,	Id.	Ibid.	pl. xxvii. fig. 62.
„ *quaterna*,	Id.	Ibid.	pl. xxvii. fig. 53;—pl. xxviii. fig. 34.
„ *rosa*,	Id.	Ibid.	pl. xxvii. fig. 54.
„ *pachyomphala*,	Id.	Ibid.	pl. xxvii. fig. 55.
„ *tracheotetras*,	Id.	Ibid.	pl. xxviii. fig. 35.
„ *perforata*,	Id.	Ibid.	pl. xxviii. fig. 36;—pl. xxix. fig. 2.
„ *protacmæa*,	Id.	Ibid.	pl. xxviii. fig. 37.
„ *laxa*,	Id.	Ibid.	pl. xxviii. fig. 38;—pl. xxix. fig. 1; pl. xxxi. fig. 42.
„ *centralis*,	Id.	Ibid.	pl. xxviii. fig. 39.

Globigerina cretacea, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 285.

Test rotaliform, much compressed; superior face flattened or only slightly convex, inferior side depressed towards the centre and excavated at the umbilicus, periphery obtuse and lobulated; composed of about three tolerably distinct convolutions, the outermost consisting of from five to seven segments; segments relatively small, subglobular; apertures opening into an umbilical vestibule. Diameter, $\frac{1}{50}$th inch (0·5 mm.).

Globigerina cretacea resembles *Globigerina dubia* in the regular Rotaliform construction of the test and in the conspicuous size of the umbilical cavity, but its contour is comparatively thin and outspread, and, though the segments are often as numerous, the entire shell seldom attains the same dimensions as that of the latter species.

The synonymy, so far as relates to Ehrenberg's figures, must be taken with a certain

amount of reservation, as it is impossible to realise properly the characters of *Globigerinæ* from their appearance as transparent objects. Some of the illustrations quoted are manifestly drawn from very young and others from immature individuals.

I have never met with recent specimens, either amongst surface-organisms or in bottom-ooze, which presented exactly the same characters as the typical Cretaceous variety; though shells similar in general conformation, and more nearly related to *Globigerina cretacea* than to any other recognised modification of the genus, are not uncommon in certain localities. Such specimens, one of which is represented in Pl. LXXXII. fig. 10, are, as a rule, more stoutly built than the typical form; and the segments are less numerous and of proportionately larger size. They are not unlike many of the fossil specimens figured by Ehrenberg.

This species is probably the commonest and most widely diffused of all the Cretaceous microzoa.

Globigerina marginata, Reuss (Woodcut, fig. 17).

Rosalina marginata, Reuss, 1845, Verstein. böhm. Kreid., pt. i. p. 36, pl. xiii. fig. 47.
„ „ Jones, 1853, Ann. and Mag. Nat. Hist., ser. 2, vol. xii. p. 241, pl. ix. fig. 7.
„ „ Reuss, 1854, Denkschr. d. k. Akad. Wiss. Wien, vol. vii. p. 69, pl. xxvi. fig. 1.
Discorbina marginata, Id., 1865, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lii. p. 12, No. 2.
Globigerina marginata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 367.
Rotalia marginata, Gümbel, 1870, Sitzungsb. d. k. bayer. Akad. Wiss., vol. ii. pp. 283, 287.
Globigerina marginata, Reuss, 1874, Das Elbthalgebirge in Sachsen, 2ter Theil, p. 112, No. 2.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 74.

Test Rotaliform, much compressed; superior face convex, inferior face also convex but with a sunken umbilical recess, peripheral edge thin or subcarinate; segments numerous, five or six in the last convolution, the outer margin of each segment exhibiting a well-marked narrow border; apertures opening into the umbilical vestibule. Surface of living specimens beset with spines. Diameter, $\frac{1}{50}$th to $\frac{1}{25}$th inch (0·5 to 1 mm.).

Messrs. Parker and Jones, in their memoir on Foraminifera from the North Atlantic and Arctic Oceans (*loc. cit.*), recognise the Globigerine affinity of the "complanate form with more or less limbate septal lines," typified by the *Rosalina marginata* of Reuss. Indeed they go somewhat further, and class together with this typical variety the *Rosalina canaliculata* of the same author, and the *Rosalina linnæana* of d'Orbigny, as pertaining to one and the same species. Of the generic affinity of the forms referred to, and of their close relationship to each other, there can be little doubt. They nevertheless appear to include representatives of two easily distinguished varieties, the one characterised by its thin subcarinate peripheral edge, the other by its thick and almost square or sometimes even bicarinate margin; and in the foregoing Scheme (p. 592) the terms *Globigerina marginata* and *Globigerina linnæana* have been retained for them respectively.

It is stated by Reuss that the entire surface of the fossil shell is hispid or beset

with short irregular spines. It will be seen by the annexed woodcut, copied from a pencil sketch of a living specimen, that during its pelagic existence the test is furnished with delicate needle-like spines; and the short points observed on the fossils are probably nothing more than the truncated ends of these.

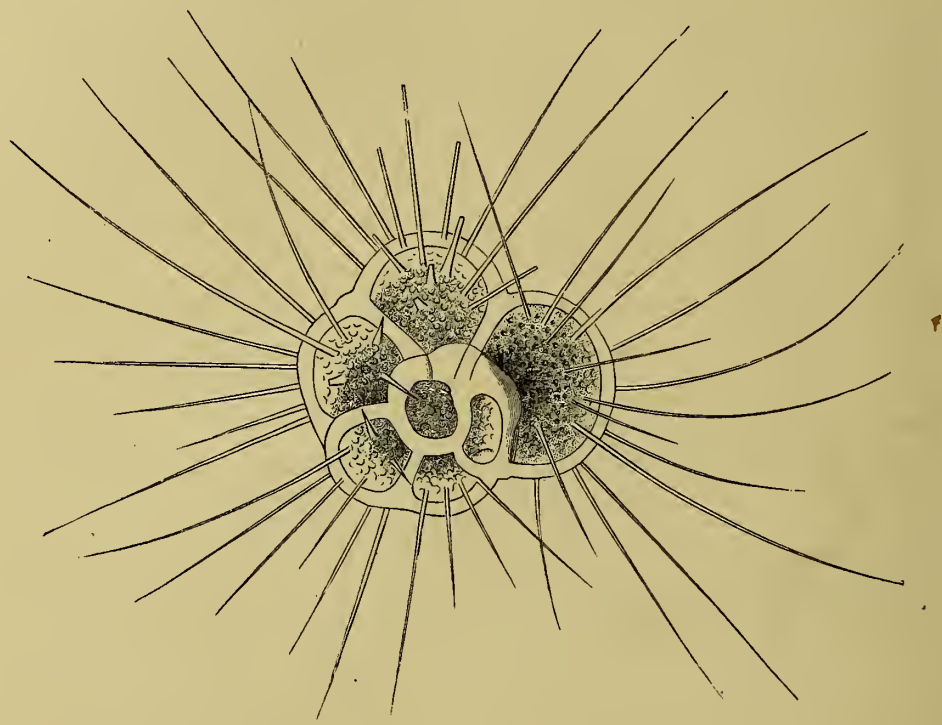

FIG. 17.—*Globigerina marginata*, Reuss. Surface specimen taken in the tow-net, off New Guinea. From a sketch by Mr. Wild.

I am unable to supply details as to the geographical distribution of *Globigerina marginata* in the living condition. It is an exceedingly rare species, and is distinguished with difficulty from its isomorph *Pulvinulina menardii*.

As a fossil it has only been found hitherto in deposits of Cretaceous age.

Globigerina linnæana, d'Orbigny, sp. (Pl. CXIV. fig. 21, *a–c*. Cretaceous specimen, Pl. LXXXII. fig. 12, *a.b.*).

Rosalina linnæana,[1] d'Orbigny, 1839, Foram. Cuba, p. 106, pl. v. figs. 10–12.
„ *canaliculata*, Reuss, 1854, Denkschr. d. k. Akad. Wiss. Wien, vol. vii. p. 70, pl. xxvi. fig. 4, *a.b.*

The following is d'Orbigny's description of this species:—"Coquille suborbiculaire, très déprimée, bicarénée sur son pourtour, un peu concave en dessous, fortement ombi-

[1] D'Orbigny writes *Linneiana* in the letterpress, *Linnei* on the plate, and *Linnæana* in the index, of the Spanish edition of the "Cuba" memoir; in the French edition *Linneiana* and *Linnæana* both appear; of these the latter is certainly preferable.

liquée, mais sans disque ombilical; la surface en est très rugueuse. Spire à peine saillante bien marquée par les bordures des loges; composée de trois tours, dont le premier est en partie masqué par des rugosités. Loges comprimées au nombre de six par tour, oblongues, aplaties en dessous; obliques, bordées tout autour d'un bourrelet; en dessous elles sont plus particulièrement bordées du côté extérieur et ombilical, mais les bourrelets sont moins marqués qu'en dessus. Ouverture sur le bord des loges dans l'ombilic. Couleur blanchâtre uniforme. Diamètre, $\frac{1}{4}$ de millim." (Foram. Cuba, French ed., p. 101. The figure Pl. CXIV. fig. 21 is copied from d'Orbigny's illustration.)

It is evident, both from the description and drawings, that the *Rosalina linnæana* of d'Orbigny is a true *Globigerina*, and nearly allied to *Globigerina marginata;* though it differs from the latter species in several minor particulars, notably in the form of the peripheral edge, which is somewhat thick and square. The general conformation of the test resembles that of *Discorbina biconcava* and *Truncatulina ariminensis*, of which the present species may be regarded as the Globigerine isomorph.

I have not been fortunate enough to meet with *Globigerina linnæana* in the living condition, but Cretaceous specimens, presenting almost identical characters, are not uncommon (Pl. LXXXII. fig. 12). Under the name *Rosalina canaliculata*, Reuss gives a good, if somewhat idealised, figure of the Cretaceous form, in his memoir on the Chalk of the Eastern Alps (*loc. cit.*), and recognises its close affinity to d'Orbigny's recent species. So far as I have been able to ascertain, there is no good ground for their specific separation.

D'Orbigny's specimens were found in shore-sands from Cuba.

Globigerina digitata, H. B. Brady (Pl. LXXX. figs. 6–10; Pl. LXXXII. figs. 6, 7).

Globigerina digitata, Brady, 1879, Quart. Journ Micr. Sci., vol. xix., N. S., p. 72.

Test spiral, more or less Rotaliform, consisting of from two to three convolutions; earlier chambers small and regular, later segments, especially the final one, elongated at their free margins and spreading radially; aperture usually large and furnished with a thickened lip or border. Diameter, $\frac{1}{65}$th inch to $\frac{1}{20}$th inch (0·4 to 1·27 mm.) or even more.

This is a singular modification of the type, in which the earlier chambers preserve the subglobular form and normal arrangement, whilst part of those of the final convolution are elongated and spreading. In some specimens, generally of small size, the terminal segment only is extended, and resembles an outstretched index-finger (Pl. LXXX. figs. 7–9), but in others, two, three, or more segments radiate in a palmate manner.

Globigerina digitata is, comparatively speaking, a very rare form, and it has never been noticed amongst pelagic organisms. A small number of examples occur in bottom-dredgings from three Stations in the South Atlantic and from six Stations in the South Pacific. The large specimens (Pl. LXXXII. figs. 6, 7) are from near the Ki

Islands, in the Eastern Archipelago, depth 580 fathoms, the only point at which the species has been found in any abundance.

Globigerina pachyderma, Ehrenberg, sp. (Pl. CXIV. figs. 19, 20).

Aristerospira pachyderma, Ehrenberg, 1873, Abhandl. d. k. Akad. Wiss. Berlin [1872], p. 386, pl. i. fig. 4.
„ *crassa*, Id. Ibid. p. 388, pl. iii. fig. 9.
Globigerina omphalotetras, Id. Ibid. p. 388, pl. iii. fig. 11.
„ *bulloides*, "arctic variety," Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 435, pl. xxi. fig. 10, *a–c*.
„ *bulloides*, var. *borealis*, Id. 1882, Proc. Roy. Soc. Edin., vol. xi. p. 716.

Test Rotaliform, subglobular, more or less compressed, peripheral edge rounded; formed of two convolutions, of which the outermost consists of four relatively large chambers; segmentation obscure externally, the sutures being very slightly depressed; aperture an arched or semicircular fissure at the margin of the final segment on its inferior side. Diameter, $\frac{1}{85}$th inch (0·3 mm.).

The small thick-shelled *Globigerina* common in cold areas, if not peculiar to them, appears to have been first named by Ehrenberg (*loc. cit.*), from specimens collected in Davis Strait,—a fact which I had previously overlooked, owing to the method pursued by the veteran German histologist of making his drawings from balsam-mounted shells, by transmitted light.

Under the name *Globigerina bulloides*, var. *borealis*, this form was noticed in the following terms:—"The test is of smaller dimensions than that of *Globigerina dutertrei*, the longer diameter of fully-grown specimens being about 0·3 mm. (that of the d'Orbignian species being 0·5 mm.), and it has fewer chambers, almost invariably four in the final convolution. The shell-wall is relatively much thicker and the aperture less conspicuous, but the habit of growth in other respects is very similar. Compared with *Globigerina bulloides*, the shell is more compactly built, its segments are less inflated and globular, and it has no umbilical vestibule" ("Knight Errant" Report, *loc. cit.*). As in the other thick-shelled varieties of the genus, the walls of the test are very distinctly perforated, but the actual diameter of the pore-canals does not exceed $\frac{1}{10,000}$th inch (0·0025 mm.).

As already stated, *Globigerina pachyderma* is peculiar to high latitudes. The most southerly point at which it has been observed is the "cold area" of the Faröe Channel, in about lat. 60° N. Within the Arctic Circle it is the most common representative of the genus, occurring sometimes alone and sometimes in company with small specimens of *Globigerina bulloides*. I have never succeeded in finding it in the tow-net gatherings, although small examples of the typical *Globigerina bulloides* are not uncommon amongst the surface organisms of the same areas.

Globigerina dutertrei, d'Orbigny (Pl. LXXXI. fig. 1, *a–c*).

Globigerina dutertrei, d'Orbigny, 1839, Foram. Cuba, p. 95, pl. iv. figs. 19–21.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 72.

Test Rotaliform, suborbicular, both faces convex, margin thick and rounded; composed of about three convolutions, the last of which consists of five segments; segments gradually increasing in size from the commencement, somewhat inflated, especially the later ones; aperture a single, arched orifice at the inferior umbilical margin of the final segment. Diameter, $\frac{1}{50}$th inch (0·5 mm.) or less.

Globigerina dutertrei is a starved variety, which to some extent takes the place of the typical *Globigerina bulloides* in the antarctic seas, just as *Globigerina pachyderma* represents the type in arctic latitudes. It has a small, compact, rounded shell, in many respects similar to the latter variety, but it is composed of a larger number of chambers, the walls are comparatively thin, and the segmentation more distinct externally. In general conformation it resembles *Globigerina dubia*, but it has no umbilical vestibule, and the test is of comparatively poor dimensions.

The most characteristic specimens of *Globigerina dutertrei* furnished by the Challenger material are from the Antarctic Ice-barrier, Stations 153 and 155, where they occur both in the surface-water and in the bottom-ooze. It is not, however, entirely confined to high latitudes, but has been found at one or two Stations in the South Pacific, and by d'Orbigny amongst the West Indies.

Globigerina inflata, d'Orbigny (Pl. LXXIX. figs. 8–10).

Globigerina inflata, d'Orbigny, 1839, Foram. Canaries, p. 134, pl. ii. figs. 7–9.
„ *rubra* (pars), Bailey, 1851, Smithsonian Contrib., vol. ii. art. 3, p. 11, figs. 20–22.
Rotalina ardasii, Seguenza, 1862, Atti dell' Accad. Gioenia, ser. 2, vol. xviii. p. 101, pl. i. figs. 5, 5*a*, *b*.
Globigerina bulloides, var. *inflata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 367, pl. xvi. figs. 16, 17.
„ *inflata*, Owen, 1867, Journ. Linn. Soc. Lond., vol. ix., Zool., p. 148, pl. v. figs. 13–15.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 72.

Test Rotaliform, superior face almost flat, inferior highly convex, periphery obtuse or rounded; composed of three convolutions, the last of which consists normally of four segments; sutures somewhat depressed externally; aperture a large, arched, gaping orifice on the outer or septal face of the terminal segment. Diameter, $\frac{1}{50}$th inch (0·5 mm.).

Globigerina inflata is a well-differentiated *Rotalia*-like variety, isomorphous with *Rotalia soldanii* and *Pulvinulina crassa*, from the latter of which it is sometimes distin-

guished with difficulty. The test has the plano-convex shape characteristic of these species, and exhibits no umbilical vestibule on its inferior surface. The only visible aperture is the large gaping orifice of the final segment, which constitutes one of the most striking features of the shell.

In point of abundance, and in the extent of its geographical range, *Globigerina inflata* stands second only to the typical *Globigerina bulloides*. Its area of distribution stretches northwards as far as lat. 82° 27′ N. and southwards to lat. 53° 55′ S. It is less common in the Arctic and Southern Oceans than elsewhere, but is equally at home in the North and South Atlantic, the North and South Pacific, the Indian Ocean, and the Mediterranean.

Its appearance as a fossil is confined to the later Tertiary formations. It has been found in the Pleistocene beds of Sicily (Seguenza) and in the Post-tertiary clays of the north-east of Ireland (Wright).

Globigerina rubra, d'Orbigny (Pl. LXXIX. figs. 11–16).

Globigerina rubra, d'Orbigny, 1839, Foram. Cuba, p. 94, pl. iv. figs. 12–14.
„ *canariensis*, Id. 1839, Foram. Canaries, p. 133, pl. ii. figs. 10–12.
„ *bulloides*, var. *rubra*, Vanden Broeck, 1876, Ann. Soc. Belge Micr., vol. ii. p. 125, pl. iii. figs. 9, 10.
„ *rubra*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 72.

Test trochoid, Rotaliform; consisting of a more or less elevated spire having about three convolutions, each convolution composed of three subglobular or inflated segments; aperture an arched or nearly semicircular opening at the inferior umbilical margin of the final segment, in addition to which some of the chambers have one or occasionally two rounded orifices on the superior face close to the sutural depressions. Colour pink, darkest in the earlier chambers. Pelagic specimens spinous externally. Diameter, $\frac{1}{50}$th inch (0·5 mm.).

This is one of the most striking varieties of *Globigerina*. It is distinguished not only by its colour, but, in typical examples, by the unusual height of the spire and by the orifices on the superior face of the test. The pink coloration is most noticeable in living or recently living individuals, but it is seldom entirely lost even in shells which are old and worn. The surface-specimens taken on the Challenger voyage are of small size and apparently not fully grown; like most of their congeners they are frequently beset with spines (fig. 16). They have a faint pink tinge, but are not nearly so well marked in this respect as many of those from bottom dredgings; it is stated, however, that tow-net specimens have been obtained amongst the West Indies of full size and of very bright hue. Other species, *e.g.*, *Globigerina sacculifera*, occasionally show traces of colour, but in no other case does it amount to a distinctive character.

The height of the spire varies considerably, the maximum being about one-third more than the diameter of the test at the broadest part. D'Orbigny describes a

Cretaceous form, *Globigerina elevata* (Mém. Soc. géol. France, vol. iv. p. 34, pl. iii. figs. 15, 16), which approaches the same relative dimensions, and Reuss has a somewhat similar variety, *Globigerina trochoides* (Haidinger's Naturw. Abhandl., vol. iv. p. 37, pl. iv. fig. 5). It is difficult to determine from the figures whether these are really distinct from the present species. Minute specimens of analogous contour, such as those portrayed in Pl. LXXXII. figs. 8, 9 are not uncommon in dredged ooze, but they generally bear the appearance of immature shells.

Globigerina rubra is found in the North and South Atlantic, the North and South Pacific, the Indian Ocean, and the Mediterranean. It is most abundant in the tropical part of the Atlantic, and is comparatively rare in the North Pacific. Its true home is in the tropics, nevertheless it spreads northwards nearly to lat. 49° N., and southwards to lat. 36° S.

Unless the Cretaceous specimens already referred to pertain to this species, there is no record of its occurrence in the fossil condition.

Globigerina conglobata, H. B. Brady (Pl. LXXX. figs. 1–5; Pl. LXXXII. fig. 5).

Globigerina conglobata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 72.

Test spiral, subglobular; earlier segments small and compactly arranged; later segments, particularly the three forming the final convolution, large and inflated, and disposed so as to form a convex base; aperture consisting of a single arched opening at the inferior umbilical margin of the final segment, and a number of rounded orifices situated in the sutural depressions of the superior face of the test; walls thick and coarsely perforated. Pelagic specimens generally more or less spinous. Diameter about $\frac{1}{35}$th inch (0·75 mm.).

This is a modification of the "*rubra*" type, in which the segments are few in number, and those of the final whorl are of preponderating size, and so combined that the test is almost equally convex on all sides. The species is in fact nearly isomorphous with *Sphæroidina bulloides*. Adult specimens are very stoutly built, the walls sometimes attaining a thickness of $\frac{1}{250}$th inch (0·1 mm.) or more. The entire shell is coarsely perforated, the pore-canals measuring about $\frac{1}{3000}$th inch (0·0084 mm.) in diameter. Surface-shells are generally found in the spinous condition.

Globigerina conglobata occurs in the tow-net collections as well as in the bottom dredgings from both North and South Atlantic and North and South Pacific. Its area of distribution appears to extend about from lat. 40° N. to lat. 35° S. (from the Azores to the Cape of Good Hope) in the Atlantic, but scarcely so far, either north or south, in the Pacific.

There is no evidence of its occurrence in the fossil state; but Reuss figures a somewhat similar form from the Vienna Tertiaries (Denkschr. d. k. Akad. Wiss. Wien, vol. i. pl. xlvii. fig. 7), as a variety of *Globigerina regularis*, d'Orbigny.

Globigerina sacculifera, H. B. Brady (Pl. LXXX. figs. 11-17; Pl. LXXXII. fig. 4).

Globigerina helicina, Carpenter, 1862, Introd. Foram., pl. xii. fig. 11.
„ *sacculifera*, Brady, 1877, Geol. Mag., Dec. II., vol. iv. p. 535.
„ „ Id. 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 73.

Test oblong, compressed, Rotaliform; segments few, usually five to seven in number, of which four generally compose the final convolution; earlier chambers small and subglobular; the ultimate segment, and sometimes also the penultimate, elongated radially and more or less pointed at the peripheral extremity. Aperture variable; consisting of a single large opening at the inferior umbilical margin of the terminal segment, and one or sometimes several rounded orifices in the sutural depressions of the superior face. Pelagic specimens spinous externally. Longer diameter $\frac{1}{25}$th inch (1 mm.) more or less.

Globigerina sacculifera is an exceedingly well-marked variety, originally described in a note on the Foraminifera of a white friable limestone from New Britain (Geol. Mag., *loc. cit.*). It belongs to the "*rubra*" section of the genus, and is characterised by its large outspread test, of which the terminal chamber or chambers are pouch-shaped or pointed. The apertures on the superior surface are numerous and that of the final segment is sometimes directly over the inferior orifice, making a passage, as it were, right through the shell. The test is thick and strongly built, resembling that of *Globigerina conglobata*. The tubulation of the walls is likewise coarse and conspicuous, the individual pores frequently showing a diameter of $\frac{1}{2500}$th inch (0·01 mm.) or more. In rare instances, notably in specimens from the West Indies (Station 24), the shells exhibit a certain amount of pink coloration. The pelagic examples collected on the Challenger Expedition were mostly in the young condition and spinous externally.

The general contour of the shell is not unlike that of the smaller specimens of *Globigerina digitata*, from which species, however, it may always be distinguished by the apertures on the superior face, and by the smaller number of segments; and generally also by its much larger dimensions.

The geographical distribution of *Globigerina sacculifera* is almost identical with that of its near ally *Globigerina conglobata*, and includes an area stretching from about 40 degrees north to 35 degrees south of the equator. Like the latter species it is most abundant in the South Pacific and least common in the North Pacific.

Some uncertainty exists as to its occurrence in the fossil state. The specimens first described were from a piece of calcareous rock supposed to be Chalk, but which on examination revealed a microzoic fauna exactly analogous to the Globigerina ooze of the tropical region of the Pacific, just south of the equator. It appears probable, therefore, that the rock in question was a compact fragment from a recent sea-bottom which had been disturbed by volcanic or other agency.

Globigerina helicina, d'Orbigny (Pl. LXXXI. figs. 4, 5).

"Polymorpha globulifera," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 119, pl. cxxx figs. *pp*, *qq*, *rr*.
Globigerina helicina, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 277, No. 5.
„ „ Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 175, pl. xi. fig. 113.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 287.

Test oblong or ovate, consisting of five or six more or less inflated chambers arranged on the normal Rotaliform plan, with the addition of one or two supplementary segments at points of the periphery out of the spiral line; aperture consisting usually of two orifices on the inferior and two or more on the superior face of the test. Longer diameter, $\frac{1}{30}$th inch (0·84 mm.).

It may be questioned whether the *Globigerina helicina* of d'Orbigny possesses characters which entitle it to rank as a zoological variety, and whether the forms it includes would not be better treated as examples of monstrous or abnormal development. Nevertheless the peculiar features of the test are tolerably constant. It most resembles an ordinary small Globigerine shell of the "*rubra*" type, with the addition of an inflated chamber at two opposite points of its periphery. The superior face is obscurely spiral, and shows two, three, or more apertures; the inferior has four visible segments, two large and oblong, laid side by side, and two small and rounded, one at each end of the test; and the latter have inferior apertures. Of the figures in Soldani's Testaceographia, referred to by d'Orbigny, that marked *qq*, which gives both the superior and inferior aspects of the shell, is the most characteristic, and leaves nothing to be desired in point of definition.

It is interesting to note that examples precisely analogous, from a morphological point of view, to those upon which this variety is founded, occur in other genera of the *Globigerinidæ*, notably in *Pullenia* and *Candeina* (Pl. LXXXIV. fig. 19, and Pl. LXXXII. fig. 19).

Globigerina helicina is a comparatively rare form. Occasional specimens have been met with at nine or ten Challenger Stations, scattered over the North and South Atlantic and the South Pacific; to which may be added, on the authority of Soldani, certain points in the Mediterranean and the Adriatic.

It occurs as a fossil in the later Tertiaries of Central and Southern Italy (Jones and Parker, Seguenza).

Globigerina æquilateralis, H. B. Brady (Pl. LXXX. figs. 18–21).

Cassidulina globulosa (pars), Egger, 1857, Neues Jahrb. für Min., &c., p. 296, pl. xi. fig. 4.
Globigerina æquilateralis, Brady, 1879, Quart Journ. Micr. Sci., vol. xix., N. S., p. 71.

Test planospiral, compressed, bilaterally symmetrical, typically evolute; consisting of rather more than a single loosely-coiled convolution; segments usually about six in

number, and all visible from either side of the shell, nearly globular in shape, the last sometimes smaller than the penultimate; aperture a large arched opening on the umbilical face of each segment. Diameter, $\frac{1}{30}$th inch (0·84 mm.), more or less.

Globigerina æquilateralis is the type of the planospiral as distinct from the Rotaliform varieties of the genus. It approaches *Hastigerina* in general contour, but the arrangement of the chambers is usually if not invariably evolute instead of involute, and the shell-wall is relatively much thicker than in the latter genus. The test is somewhat finely porous, the perforations measuring about $\frac{1}{6000}$th to $\frac{1}{5000}$th inch (0·0042 to 0·005 mm.) in diameter. So far as has been observed, the surface specimens do not manifest to the same extent as those of many other species the tendency to assume a spinous condition.

Globigerina æquilateralis occurs amongst the surface-microzoa from the North Atlantic and the North and South Pacific. It has also been found in the South Atlantic but only in bottom-dredgings. Its area of distribution appears to extend from off the south-west corner of Ireland, lat. 50° N., to the Cape of Good Hope, about lat. 35° S.

There can be little doubt that one of the specimens figured by Egger under the name *Cassidulina globulosa* belongs to the present species, so that its geological history dates back at least as far as the Miocene period. Ehrenberg gives a drawing of a very similar form, possibly the same (*Phanerostomum asperum*, Mikrogeologie, pl. xxx. fig. 26, *a.b.*) from the Chalk of the Island of Rügen.

Orbulina, d'Orbigny.

Orbulina, d'Orbigny [1839], Reuss, Bailey, Costa, Williamson, Parker and Jones, Karrer, Carpenter, Wallich, Seguenza, Terquem, Brady, Alcock, Dawson, Fischer, &c.
Miliola, pars; *Monocystis*, Ehrenberg [1854].
Globigerina, pars, d'Orbigny [1846], Pourtales, Reuss, Alcock, Owen, Brady, Seguenza.

The genus *Orbulina* was first brought into notice by d'Orbigny in his memoir on Cuban Foraminifera, but the author appears to have been previously well acquainted with the typical species from specimens collected on the shores of the Adriatic and elsewhere.

The original generic description runs as follows:—"Shell free, regular, spherical, globular, interior hollow; pierced in every part by a large number of minute pores only visible when highly magnified; aperture small, rounded, placed at a point of the circumference;" to which is appended the remark "it is possible that under certain circumstances the animal is able to close the aperture of the shell, at any rate it is not always visible, and it is only open in one-sixth of the freshly collected specimens" (Foram. Cuba, p. 34).

Williamson states that "the septal aperture of *Orbulina universa* is small; normally

round, but usually irregular, and sometimes entirely closed up by the inspissated gelatinous sarcode, so as to be invisible" (Rec. For. Gt. Br., p. 2). His figure of the species, which corresponds accurately with that in d'Orbigny's work, is copied in Pl. LXXXI. fig. 25.

The conspicuous characters, so far as they can be gathered from the majority of bottom specimens, are fairly indicated by these descriptions; but it will be presently shown that it is more than doubtful whether, in the typical condition, the shell ever possesses an aperture, in the ordinary sense of the term; and that the more or less regular openings which have been occasionally mistaken for the general orifice are probably in all cases the result of the accidental enlargement of ordinary pores.

That the test does not always consist of a simple undivided chamber was first demonstrated by Pourtales, who in a brief note on the genera *Orbulina* and *Globigerina* announced that during the examination of "large numbers of well-preserved specimens obtained from the bottom beneath the Gulf Stream," he had "found in nearly one half of the *Orbulinæ* examined, young *Globigerinæ* more or less developed and attached to the inside of the *Orbulina* by numerous very slender spiculæ."[1] Similar observations were made a few years later by Alcock upon shells found in littoral sands from the west coast of Ireland.[2] The same fact had been observed in living pelagic specimens by Krohn, as early as 1860,[3] some time prior to the publication of Major Owen's well-known memoir on Surface Foraminifera.[4] Carpenter, in his review of the observations made by Pourtales, states that "after having carefully laid open, by the application of weak acid, the spheres of a considerable number of *Orbulinæ*," he had "not met with a *Globigerina* in a single one."[5] For myself, though I have never encountered the *Globigerina*-like internal shells in *Orbulinæ* from bottom-dredgings, to anything like the extent indicated by the American author, I have not unfrequently found them in a certain proportion of the specimens so obtained.[6]

[1] *Amer. Journ. Sci. and Arts*, 1858, vol. xxvi. p. 96.

[2] *Mem. Lit. and Phil. Soc. Manchester*, 1865, ser. 3, vol. iii. p. 180.

[3] *Fide* Schultze, *Wiegmann's Archiv*, 1860.—Transl., *Ann. and Mag. Nat. Hist.*, ser. 3, vol. vii. p. 312.

[4] *Journ. Linn. Soc. Lond.*, 1867, vol. ix., Zool., p. 149.

[5] Introd. Foram., p. 178.

[6] Since these sheets have been in the hands of the printer, I have received from the author, Herr G. Schacko of Berlin, an interesting and elaborate paper entitled "Globigerinen Einschluss bei Orbulina" (*Wiegmann's Archiv*, Jahrg. xlix. p. 428), which offers a reasonable explanation of these apparent discrepancies. Shacko's investigations, which refer to bottom-specimens, both recent and fossil, tend to show that the Globigerine shell is most conspicuous in comparatively small *Orbulinæ*. He states that in a sphere of 0·3 mm. diameter, the Globigerine chambers occupied two-thirds of the cavity of the test; that one of 0·7 mm. diameter contained a *Globigerina* of 0·5 mm. diameter; that in one of 0·8 mm. diameter the Globigerine shell measured only 0·2 mm.; whilst a specimen of still larger size, between 0·8 mm. and 0·9 mm., contained scarcely a recognisable trace of a Globigerine shell. Hence it would appear that in ordinary thick-walled bottom-specimens, the Globigerine shell has its maximum development in *Orbulinæ* of about 0·7 mm. diameter; and that in spheres of more than 0·8 mm. it is either of insignificant size or entirely absent, in the latter case probably resorbed during the thickening of the outer wall.

Broadly speaking, this accords with my own observations. I have never found a Globigerine shell in the interior of a very large bottom-*Orbulina*, and very rarely in one that could be called full-sized; but they are not uncommon in middle-sized and small specimens.

The characters of the genus *Orbulina* are best studied in connection with the typical species *Orbulina universa*, from which the varietal modifications differ only in superficial ornament and similar minor details. Of the close relationship that exists between *Orbulina* and *Globigerina* there can be no doubt, and by some writers the former is treated as a subgeneric section of the latter genus. I was at first disposed to accept this view. It involves the supposition that the internal polythalamous shell is an actual *Globigerina*, of which the visible spherical chamber is the final segment. Morphologically speaking there is nothing unreasonable in such an explanation; at the same time, the adult test has characters as well marked and as constant as those which are employed to distinguish many other genera of Foraminifera, and it appears on the whole advantageous to recognise both generic terms.

The limits of the distribution of the genus, whether geographical or geological, are those of the typical species, *Orbulina universa*.

Orbulina universa, d'Orbigny (Pl. LXXVIII.; Pl. LXXXI. figs. 8–26; Pl. LXXXII. fig. 1–3).

"Polymorpha *Sphærulæ vitreæ*," Soldani, 1791, Testaceographia, vol. i. pt. 2, p. 116, pl. cxix. figs. *I.–N.*

Orbulina universa, d'Orbigny, 1839, Foram. Cuba, p. 3, pl. i. fig. 1.

„ „ Id. 1839, Foram. Canaries, p. 122, pl. i. fig. 1.

Miliola (*Monocystis*) *arcella*, Ehrenberg, 1854, Mikrogeologie, pl. xxx. fig. 1.

„ *sphærula*, Id. Ibid. pl. xxxi. fig. 1, *a.b.c.*

Orbulina granulata, var. *atra*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 116, pl. xi. fig. 2.

„ „ var. *areolata*, Id. Ibid. p. 117, pl. xi. fig. 4.

„ *universa*, Id. Ibid. p. 114, pl. xi. fig. 5.

„ Williamson, 1858, Rec. For. Gt. Br., p. 2, pl. i. fig. 4.

„ *punctata*, Terquem, 1862, Foram. du Lias, 2ième mém., p. 432, pl. v. fig. 5.

Globigerina (*Orbulina*) *universa*, Owen, 1867, Journ. Linn. Soc. Lond., vol. ix., Zool., p. 149, pl. v. fig. 1.

„ „ *continens*, Id. Ibid. figs. 3, 4.

„ „ *acerosa*, Id. Ibid. fig. 2.

„ „ *universa*, Brady, 1859, Quart Journ Micr. Sci., vol. xix., N. S., p. 75.

Double specimens (Pl. LXXXI. figs. 20, 21; Pl. LXXXII. figs. 2, 3).

Globigerina bilobata, d'Orbigny, 1846, For. Foss. Vien., p. 164, pl. ix. figs. 11–14.

Orbulina granulata, var. *impressa*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 117, pl. xi. fig. 4.

Globigerina bipartita, Reuss, 1863, Bull. Acad. Roy. Belg., ser. 2, vol. xv. p. 156, pl. iii. fig. 46.

„ *ovoidea*, Seguenza, 1880, Mem. R. Accad. dei Lincei, ser. 3, vol. vi. p. 228, pl. xvii. fig. 39.

Orbulina universa is one of the commonest of pelagic Foraminifera. This fact has only been generally recognised of late years, and the earlier descriptions of the species

are founded upon bottom-specimens, which differ in important respects from those taken at the surface of the ocean.

The outer or visible test consists of a single spherical chamber, the exterior of which, in surface-specimens, is almost always more or less beset with spines. The spines are sometimes so short and minute as to be scarcely perceptible, but more frequently they take the form of slender needle-like spicula of considerable length (Pl. LXXVIII.; Pl. LXXXI. figs. 12–14, 24, &c.). In the interior of the chamber of surface-specimens, there is usually, if not invariably, a polythalamous *Globigerina*-like shell, which is more or less apparent through the hyaline walls of the outer test. The internal shell is also beset with spines, and its segments are partially or entirely filled with coloured sarcode, as shown in the two figures Pl. LXXXI. figs. 18, 19, drawn from specimens from which the outer test has been removed. The external test of pelagic specimens is a calcareous film of extreme tenuity. I have been unable hitherto to obtain any satisfactory measurement of its thickness. The dimensions of the test vary a good deal; large examples sometimes attain a diameter of $\frac{1}{30}$th inch (0·84 mm.). The walls are in all cases distinctly perforated, but they have nothing resembling a general aperture.

Bottom-specimens differ from those taken at the surface much more in the thickness of the walls than in the external dimensions of the test. The shell is seldom much more than $\frac{1}{30}$th inch (0·84 mm.) in diameter, but the walls of average full-sized examples are from $\frac{1}{900}$th to $\frac{1}{400}$th inch (0·028 to 0·063 mm.) in thickness. The outer surface is never spinous, but is either smooth (Pl. LXXXI. fig. 25) or granular (figs. 9, 11), or even slightly tuberculate (fig. 23). The minute specimens which are found in comparatively shallow water (fig. 10) are commonly of a brown colour, and more or less areolated externally.

The perforations are usually very distinct, and they are commonly of two sorts, differing in point of size (Pl. LXXXI. figs. 8, 22, &c.). Thus in one example, from which measurements have been taken, the larger pores show a tolerably uniform diameter of about $\frac{1}{1200}$th inch (0·021 mm.), the smaller series of about $\frac{1}{5000}$th inch (0·005 mm.); whilst in another the diameters are $\frac{1}{1900}$th inch (0·013 mm.) and $\frac{1}{4000}$th inch (0·0063 mm.) respectively. But no general rule can be laid down, inasmuch as in a certain proportion of specimens the pores are practically all alike, presenting an intermediate diameter of about $\frac{1}{3300}$th inch (0·0077 mm.).

D'Orbigny describes and figures the aperture of *Orbulina universa* as a rounded orifice, but states that he had only been able to find it in about one-sixth of the specimens he had collected. After the careful examination of thousands of bottom specimens I have not succeeded in obtaining one with an orifice that can be affirmed with any certainty to be the natural aperture. Openings approximately circular are occasionally met with, sometimes more than one in a shell, but the edges are invariably rough and abrupt, as though the result of fracture (Pl. LXXXI. fig. 20), and they lack the smooth neatly-finished aspect which is a common feature of the mouth of a Foraminifer. Under

these circumstances the conclusion seems obvious that the shell of *Orbulina* in its typical condition has no general aperture, in the sense in which that term is ordinarily employed.[1]

With reference to the existence of a distinct series of larger pores it is interesting to note the collateral fact, that in certain other genera of Foraminifera, where a final segment of abnormal size is formed, such, for example, as the balloon-shaped chamber of *Cymbalopora bulloides*, or the inflated terminal segment of *Pulvinulina lateralis*, the ordinary aperture is more or less replaced by a number of exceptionally large perforations scattered over the face of the outermost chamber.

Thick-shelled bottom specimens of *Orbulina* frequently exhibit a curious lamination of the walls of the test, affording clear evidence that the increase in thickness has taken place not as a continuous deposit but by the formation of successive layers of calcareous matter. An illustration of this phenomenon is shown in Pl. LXXXI. fig. 26, which represents a shell formed of at least four concentric laminæ. This structure is best seen in old and worn specimens, and it is quite possible, though the layers are well-defined and the enclosed spheres loose and easily separated, that the entire wall may have been compact and to all appearance homogeneous during the life of the animal; in other words, that the visible separation into laminæ may be the first stage in the disintegration of the shell. There are, however, rare instances of living surface-specimens with a double shell-wall, and in one case a threefold shell has been observed; but in all these the calcareous laminæ are of extreme tenuity, and bear little actual resemblance to the coats of the bottom-specimens.

As has been already stated (p. 607), bottom-specimens have occasionally been found, which, like those from surface gatherings, contain a polythalamous nucleus. These, however, are comparatively rare and of somewhat local distribution. In dredged specimens, as a rule, the cavity of the test is undivided and seldom contains any trace of an internal skeleton; if, therefore, the *Globigerina*-like inner shell is an invariable feature of the early stages of growth, which is by no means proved, it is probably absorbed during the process of thickening of the outer walls.

In bottom-ooze, in which *Orbulinæ* abound, two-chambered shells are not unfrequently met with. They consist of the normal spherical test with an adherent supplementary chamber. Sometimes the added segment is larger than the original test, as in two of the figured specimens, Pl. LXXXI. fig. 20, and Pl. LXXXII. fig. 2; in other cases it is of about the same size, as shown in Pl. LXXXI. fig. 21. Such forms constitute the *Globigerina bilobata* of d'Orbigny. More rarely shells with two supplementary chambers present themselves, of which Pl. LXXXII. fig. 3 is an example. In all these cases the chambers have the true Orbuline character, and the test has nothing resembling a Globigerine aperture, indeed it seldom possesses any aperture at all. From a morpho-

[1] Shacko's recent observations entirely confirm this view (*op. cit.*), p. 433. On the other hand it is right to state that Wallich entertains the contrary opinion (*Deep-sea Researches on the Biology of Globigerina*, p. 74).

logical point of view the di- or tri-thalamous condition is nothing more than an abnormal or accidental development of the typical form.

In point of distribution *Orbulina universa* is a cosmopolitan species. It has been taken in the tow-net as far north as the Faröe Channel, and thence southward as far as lat. 32° 24′ S. in the Atlantic, and 45° 31′ S. in the Pacific. In bottom-dredgings its occurrence has been noted at every latitude from the shores of Novaya-Zemlya, lat. 76° 59′ N., almost to Magellans Strait, lat. 50° 10′ S. It inhabits all the great oceans, the Red Sea, the Mediterranean, and the Adriatic. In some areas the shells exist in enormous numbers; and at certain points in the North Atlantic, two or three degrees south and south-west of Ireland, explored on the second "Porcupine" cruise, they form one of the most important constituents of the bottom-ooze.[1]

The earliest geological appearance of the species is in the Lias of the Moselle (Terquem). It has been noticed in certain Jurassic limestones of the Canton Aargau, Switzerland (Haeusler), and in the Chalk of the Island of Rügen, and at Volsk in Russia (Ehrenberg). It occurs in the Septaria-Clays and in the Upper Oligocene formations of Germany (Reuss); in the Miocene of the Vienna Basin (d'Orbigny, Reuss, Karrer), and of Malta (Brady); in the Salzthon of Wieliczka (Reuss), and in the later Tertiaries of Central and Southern Italy (d'Orbigny, Costa, Terrigi, &c.).[2]

Orbulina porosa, Terquem (Pl. LXXXI. fig. 27).

Globulina porosa, Terquem, 1858, Foram. du Lias, 1ière mém., p. 633, *fide* Terquem.
Orbulina liasica, Id. 1862, Ibid. 2ième mém., p. 432, pl. v. fig. 4.
„ *foveolata* (?), Seguenza, 1862, Foram. Monotal. Mess., p. 37, pl. i. figs. 1, 2.
„ *neojurensis*, Karrer, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 368, pl. iii. fig. 10.
„ „ Norman, 1876, Proc. Roy. Soc., vol. xxv. pp. 213, 214.
Globigerina (*Orbulina*) *neojurensis*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S. p. 76.
„ „ „ Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 186, pl. i. fig. 16.

The shell of this species is spherical and coarsely perforated, and the pores are surrounded externally by exogenous ridges which mark out the surface into

[1] Samples of the bottom-ooze from "Porcupine" Stations 36 and 42, as they reached my hands, were almost entirely composed of *Orbulinæ*. It has been suggested that the material from these points had been partially washed on shipboard. I have no certain knowledge that this is the case, but it seems not improbable, inasmuch as in another sample from Station 42, preserved by Sir Wyville Thomson, the same preponderance is not apparent. Nevertheless, it is a significant fact that *Orbulinæ* do exist in these enormous numbers, and their abundance in proportion to other organisms of similar size is not diminished by the suggested explanation.

[2] Abich, in a recently published memoir (Geol. Forsch. in den kaukasischen Ländern, II. Th., 1 Westhälfte, p. 240, pl. xi. fig. 8) has described an early Tertiary rock from the region of the Caucasus as an *Orbulina*-limestone ("Orbulinenkalk"). It is evident, however, both from the description and figure, that this is nothing more than one of those calcareous deposits formed of oolitic grains, which are to be met with in formations of every age, from the Silurian

rounded or polygonal areæ. The few recent specimens that have come under my notice have tolerably regular and well-formed apertures, as shown in the figure; but the edges are somewhat square and abrupt, and it is not improbable that they may have a similar origin to those occasionally found in bottom specimens of *Orbulina universa*.

The earliest satisfactory drawing of *Orbulina porosa* is that given by Terquem under the name *Orbulina liasica;* but in his description of the species it is stated that the organism is the same as that which he had previously named *Globulina porosa*. Having the choice of two specific terms, I have preferred the earlier, not only on the ground of precedence, but because it happens to be more appropriate to a still-living organism.

Orbulina porosa is an exceedingly rare Foraminifer. It does not occur in any of the pelagic collections, although *Globigerinæ* with similar superficial markings are not uncommon at certain points; and it has only been recognised in the bottom dredgings from one Challenger Station,—off Culebra Island, West Indies, 390 fathoms. It has, however, been found by the Rev. A. M. Norman in two of the "Valorous" soundings in the North Atlantic, namely, Station 9, depth 1750 fathoms, and Station 15, depth 1485 fathoms.

In the fossil state it has been observed in the Lias of the Moselle (Terquem), in the White Jura of St. Veit, near Vienna (Karrer), and in the Pliocene Sands of the neighbourhood of Rome (Terrigi).

Hastigerina, Wyville Thomson.

Nonionina, pars, d'Orbigny [1839], Ehrenberg.
Lituola, pars, Jones and Parker [1860].
Globigerina, pars, Parker and Jones [1865].
Hastigerina, Wyville Thomson [1876], Brady.

The genus *Hastigerina* was instituted by Sir Wyville Thomson for certain *Globigerina*-like organisms, obtained by means of the tow-net from the surface-water of mid-ocean. Similar specimens had been collected many years previously, under the same conditions, by d'Orbigny, but were assigned by him to the genus *Nonionina*.

Hastigerina is essentially a pelagic type. The surface-specimens present considerable variety of contour, but they are all referrible to a single species, the salient characters of which are set forth in the subjoined description.

forward to comparatively recent periods. The spherules are not of organic origin, but are the result of the coalescence of precipitated or finely comminuted carbonate of lime, in accordance with purely physical laws (*vide*, Monogr. Carb. and Perm. Foraminifera, p. 5). So far as I am aware, *Orbulinæ* have never been found in the fossil condition in sufficient numbers to constitute any sensible proportion of a geological deposit.

Hastigerina pelagica, d'Orbigny, sp. (Pl. LXXXIII. figs. 1–8).

Nonionina pelagica, d'Orbigny, 1839, Foram. Amér. Mérid., p. 27, pl. iii. figs. 13, 14.
Lituola pelagica, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 302, table No. 181.
Globigerina pelagica, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 366.
Nonionina hyalina, Ehrenberg, 1873, Abhandl. d. k. Akad. Wiss. Berlin (1872), p. 388, pl. iv. fig. 4.
Hastigerina murrayi, Wy. Thomson, 1876, Proc. Roy. Soc., vol. xxiv. p. 534, pls. xxii., xxiii.
„ *pelagica*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 77.

The test of *Hastigerina pelagica* is a nautiloid spire, either subglobular in contour or more or less compressed bilaterally, with excavated umbilici and lobulated periphery. Adult specimens attain a diameter of about $\frac{1}{30}$th inch (0·84 mm.).

It is composed of somewhat less than two convolutions, of which the later, consisting of either five or six segments, completely encloses the earlier portions. The segments are much inflated, and each successively considerably larger than its predecessor. The aperture is a broad oval or arched opening, symmetrically placed at the inner margin of the final segment, sometimes bordered with a slightly thickened lip. The shell-wall is exceedingly delicate and transparent, and in living specimens is so thin that the outline of the enclosed chambers and the form of the sarcode-lobes can be plainly traced by transmitted light. The pseudopodial perforations are very numerous and almost as minute as those of *Sphæroidina bulloides*, that is to say, about $\frac{1}{8000}$th inch (0·003 mm.) in diameter, but they appear somewhat larger in worn bottom specimens. The surface of the test is beset with long, slender, needle-like spines, the sides of which are distinctly serrate, especially near the base. They are usually swollen at the point of union with the shell, and a slight constriction may generally be observed immediately above the thickened base. In some cases the spines appear to be hollow, but whether this is the rule, or indeed whether the appearance may not be due to the mode in which the specimens are mounted, I am unable to say with certainty.

The species was repeatedly taken by means of the tow-net during the Challenger voyage, and the central figure of Pl. LXXXIII. is copied from a drawing made by Mr. Wild from a living specimen. This is referred to by Mr. Murray in one of the Preliminary Reports[1] in the following terms:—"At times calcareous Foraminifera occur in vast numbers on the surface, and with a bottle can be picked up from a boat. In one specimen thus procured the sarcode of the animal was found thrown out into bubble-like extensions between the spines of the shell, and over these expansions of the sarcode and along the spines the pseudopodia moved freely and rapidly."

Hastigerina pelagica may be readily identified by the foregoing characters. The

[1] *Proc. Roy. Soc.*, vol. xxiv. p 534.

only Foraminifer with which it is likely to be confounded is *Globigerina æquilateralis;* but in that species the shell is more compressed and the spire evolute; the walls are thicker, the perforations larger, and the aperture comparatively small and inconspicuous; besides which the surface is rarely spinous, and the spines, when present, are small and not serrated.

To the original description in the "South America" memoir, d'Orbigny appends the following remark :—"Cette espèce est une rare exception parmi les Foraminifères essentiellement côtiers, puisque nous l'avons prise en pleine mer, à une grande distance des côtes du Pérou, dans l'océan Pacifique, par 20° de latitude sud et 89° de longitude ouest de Paris, où elle nous a paru très rare." Even now, with a much wider knowledge of the life-conditions of the Foraminifera, *Hastigerina pelagica* is one of the very small number of species of which it can be said with any approach to certainty that it lives only at the surface of the ocean. A few of the thicker-shelled specimens are found from time to time in bottom-dredgings, but they are by no means common, and are seldom even approximately complete. The spines are invariably broken off, and when the shells are not otherwise fractured the surfaces are worn and the texture rotten. Of these figs. 5–8 are fair examples.

Living specimens of *Hastigerina pelagica* were collected by the Challenger naturalists at five points in the North Atlantic, at two in the South Atlantic, at three in the South Pacific, and at twelve in the North Pacific; and on the cruise of the "Triton" in 1882, the species was obtained in great abundance in the Faröe Channel. Dead shells have been noticed in the dredged material from three Stations in the North Atlantic, from five in the South Atlantic, and from three in the South Pacific, as well as in sands from the Gulf of Suez.

No fossil remains of the species have hitherto been recognised.

Pullenia, Parker and Jones.

Nonionina, pars, d'Orbigny [1826], Reuss, Bornemann, Costa, Parker and Jones, Karrer, Schlicht.

Pullenia, Parker and Jones [1862], Carpenter, Reuss, Karrer, Pourtales, M. Sars, Miller and Vanden Broeck, Hantken, Wright, Norman, Brady, Marsson, Seguenza, &c.

The zoological features of the genus *Pullenia* have been variously estimated by different systematists. By d'Orbigny and other earlier authors the typical species were placed amongst *Nonioninæ*, and it was not until 1862 that their distinct structure and affinities were pointed out by Parker and Jones. In Carpenter's "Introduction" the genus was classed in the Sub-family *Globigerinæ*, between *Globigerina* and *Sphæroidina*, but this mode of treatment has not hitherto met with general acceptance. Reuss, even in his

later memoirs, associates *Pullenia* with *Cristellaria* to form the Family Cristellaridea,[1] and the same course is adopted by Hantken.[2] Schwager makes the genus the type of a distinct Family, Pullenidæ, which includes *Nonionina*, *Polystomella*, *Fusulina*, and *Melonia*;[3] whilst with Bütschli it serves as the type of the *Pullenin*æ, a Sub-family of Nummulitinæ, and is therein associated with *Sphæroidina*, *Endothyra*, *Amphistegina*, &c.[4]

The test of *Pullenia* is a nautiloid spire of two to four convolutions, either regular and equilateral in its mode of growth or one-sided and oblique, each convolution completely enclosing the preceding one. The segments number four to six in each circuit; the sutures are flush in the smaller varieties, whilst those of the larger forms are somewhat depressed externally. The septal face is comparatively narrow, and the aperture is either an arched fissure extending nearly from pole to pole, or in the oblique forms a long gaping orifice at the inner border of the final segment. The surface of the shell is smooth and glassy, and the pores are very minute, as compared with those of most of the other Globigerine types.

The separation of *Pullenia* from *Nonionina*, to which it has considerable resemblance at first sight, is dictated partly by the nature of the aperture and partly by the absence of the Polystomelline characters, which, though often feebly developed, may always be detected in one guise or other in specimens of the latter genus. The relationship of the large, oblique, subglobular forms of *Pullenia* to *Sphæroidina* and *Globigerina* is tolerably apparent when a number of specimens are seen together, and the affinity of the three genera is further suggested by their remarkable similarity of distribution.

Of the three recent species of *Pullenia*, one has been taken living at the surface of the open sea, the others are known only from bottom-specimens. The genus has been found at every latitude and at almost every depth hitherto explored by sounding-line or dredge. It is also a well-known fossil type, occurring in marine strata of every geological age from the middle of the Cretaceous period down to recent times.

Pullenia sphæroides, d'Orbigny, sp. (Pl. LXXXIV. figs. 12, 13).

Nonionina sphæroides, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 293, No. 1.—Modèle, No. 43.
„ *bulloides*, Id. Ibid. p. 293, No. 2 (name only).
„ „ Id. 1846, For. Foss. Vien., p. 107, pl. v. figs.8–10.
„ *quaternaria*, Reuss, 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 34, pl. iii. fig. 13.

[1] *Denkschr. d. k. Akad. Wiss. Wien*, 1866, vol. xxv. p. 206.
[2] *Mitth. Jahrb. d. k. ung. geol. Anstalt*, vol. iv. p. 59.
[3] Saggio di una Classificazione dei Foraminiferi, p. 14.
[4] Bronn, Kl. u. Ord. des Thier-Reichs, 1880, vol. i. p. 210.

Pullenia sphæroides, Carpenter, 1862, Introd. Foram., p. 184, pl. xii. fig. 12.
„ „ Parker and Jones, 1865, Phil. Trans., vol. clv. p. 368, pl. xiv. figs. 43, *a.b.*
„ *bulloides*, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 150.
„ *sphæroides*, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 189, pl. i. fig. 21.

In general external appearance *Pullenia sphæroides* bears a close resemblance to the thicker varieties of the genus *Nonionina*. It is a minute species, perhaps the smallest of all the *Globigerinidæ*, the diameter of the adult test ranging from $\frac{1}{150}$th to $\frac{1}{75}$th inch (0·17 mm. to 0·34 mm.). The shell is subglobular, usually somewhat compressed in the direction of the axis; and it is composed of from three to four convolutions, each of which consists normally of four segments. The segments are much arched and extend from pole to pole, so that each convolution completely invests those previously formed. The septal face is extremely narrow; and the aperture is a crescentiform slit, almost the entire length of the final segment, inserted at its inner margin, close to the line of union with the preceding convolution. The surface of the shell is smooth, and the sutures are marked externally by fine lines with little or no superficial depression. The walls are very finely perforated; and, judging from the appearance of transverse sections of the shell, the diameter of the pore-canals does not exceed $\frac{1}{25,000}$th inch (0·001 mm.).

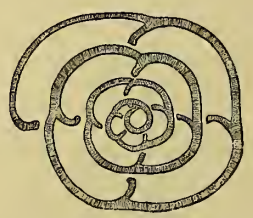

Fig. 18. — *Pullenia sphæroides*. Horizontal section, showing the arrangement of the chambers. Magnified 100 diameters.

Pullenia sphæroides is a nearly cosmopolitan species. Its area of distribution reaches from lat. 70° N., or thereabouts, to lat. 54° S.; and its bathymetric range extends from the laminarian zone down to 2750 fathoms, but it is comparatively rare at depths of less than 300 fathoms. The list of localities includes Davis Strait and the shores of Novaya Zemlya, the east coast of Norway, the Faröe Channel, the British seas, the Mediterranean, and the Red Sea: its occurrence has been noted at no less than twenty-two Stations in the North Atlantic, six in the South Atlantic, four in the Southern Ocean, fifteen in the South Pacific, and five in the North Pacific.

From a geological point of view, *Pullenia sphæroides* is first conspicuous as a Cretaceous Foraminifer. It presents itself in the Chalk of Westphalia (Reuss) and of the Island of Rügen (Marsson), and in the Chalk-marl of Lemberg (Reuss). It is found in the Eocene clay of the London Basin (Jones and Parker), and in the Septaria-clays of various parts of Germany (Reuss, Bornemann); in the Miocene deposits of Vienna (d'Orbigny, Reuss, Karrer), of the Banat (Karrer), and of Malta (Brady), and in the Salzthon of Wieliczka (Reuss). It occurs also in the Subapennine formations of Italy (d'Orbigny, Costa, &c.), in the Vatican Sands (Terrigi), and in the Crag of Norfolk and Suffolk (Jones, Parker, and Brady).

Pullenia quinqueloba, Reuss (Pl. LXXXIV. figs. 14, 15).

Nonionina quinqueloba, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 47, pl. v. fig. 31, *a.b.*
„ „ Bornemann, 1855, Ibid. vol. vii. p. 339.
Pullenia sphæroides (pars), Parker and Jones, 1865, Phil. Trans., vol. clv. p. 368, pl. xvii. fig. 53.
„ *compressiuscula*, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 150.
„ „ var. *a*, *quinqueloba*; var. *β quadriloba*, Reuss, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 87, pl. iii. fig. 8, *a.b.*
„ *sphæroides*, var. *quinqueloba*, Miller and Vanden Broeck, 1873, Ann. Soc. Malac. Belg., vol. vi. p. 39, No. 17.
„ *compressa*, Seguenza, 1879, Formazioni Terz. nella Reggio, p. 221, pl. xvii. figs. 14, 14*a*.
„ *quinqueloba*, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 712.

The test of *Pullenia quinqueloba* differs from that of the typical *Pullenia sphæroides* in its larger dimensions and its more or less flattened contour. In general conformation it is nautiloid and biconvex, with the peripheral edge obtuse or rounded; and the final convolution, which consists normally of five segments (rarely four or six) entirely conceals the preceding whorls. Externally the segments are slightly inflated, and the sutural lines correspondingly depressed. The shell sometimes attains a diameter of $\frac{1}{35}$th inch (0·72 mm.).

The specimens of this species dredged off Prince Edward Island, at which locality it is exceedingly abundant, displayed a remarkable variety of tint when first taken out of fluid. This appearance was occasioned by the high colour of the animal inhabiting the shell, which in some cases was of olive-green hue, in others yellow, and in others pink.

Pullenia quinqueloba has nearly the same wide geographical and bathymetrical distribution as *Pullenia sphæroides*, but it appears to attain its best development in the southern hemisphere. Like the typical species, it is known only from bottom-specimens, and there is no reason to suppose that it ever lives at the surface of the ocean. It has been found as far north as lat. 62° 6′ N. in the North Atlantic, and southwards to the Antarctic Ice-barrier, lat. 64° 18′ S., and its range of depth extends from 20 or 30 fathoms to 2750 fathoms. It is common in the "warm area" of the Faröe Channel, and occurs sparingly on the shores of Great Britain and Belgium, in the Mediterranean and the Red Sea. Notes have been kept of its occurrence at nineteen Stations in the North Atlantic, at six in the South Atlantic, at five in the Southern Ocean, at fifteen in the South Pacific, and at two in the North Pacific.

As a fossil it has been noticed in the Chalk of the north of Ireland (Wright), and of the Island of Rügen (Marsson); in the Barton Beds of the Isle of Wight (Brady), in the Septaria-clays of Germany (Reuss, Bornemann), in the Miocene deposits of the Vienna Basin (Reuss) and the Banat (Karrer); in the Salzthon of Wieliczka, and in the Crag of Antwerp (Reuss), and in the Upper Tertiaries of Southern Italy (Seguenza).

Pullenia obliquiloculata, Parker and Jones (Pl. LXXXIV. figs. 16–20).

Pullenia obliquiloculata, Parker and Jones (1862, Introd. Foram., p. 183);—1865, Phil. Trans., vol. clv. p. 368, 421, pl. xix. fig. 4.
„ „ Pourtales, 1867, Bull. Mus. Comp. Zool. Camb. (1867), p. 107.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 294.

This species is only incidentally mentioned by Parker and Jones (*loc. cit.*) as "another form of *Pullenia*," which "has the chambers set on obliquely"; and though it is one of the most important constituents of the Globigerina ooze of tropical latitudes, it has passed almost unnoticed by subsequent observers.

The test is subglobular, inequilateral, and somewhat compressed; and its mode of growth irregularly nautiloid, the successive whorls not being on the same plane. It is larger than either of its congeners, fully-grown specimens attaining a diameter of about $\frac{1}{30}$th inch (0·84 mm.). The shell is composed of from two to three convolutions, of which the latest, consisting usually of four or five segments, is alone visible externally. The segments are inflated, and the sutural lines marked by slight depressions. The aperture is a long oval or crescentic opening on the inner margin of the final segment, generally obliquely set. Its superior border is rounded, owing to the turning inwards of the edge of the shell, as shown in the sectional drawing (fig. 20). The surface of the test is smooth and polished. The perforations, although larger than in *Pullenia sphæroides*, are minute as compared with those of many of the Globigerinidæ. In thin sections of the shell they have the appearance of tubular canals of $\frac{1}{5000}$th or $\frac{1}{4000}$th inch (0·005 or 0·0063 mm.) diameter.

Pullenia obliquiloculata is the only variety of the genus which has been found living in the surface-water of the ocean, but that it is exclusively a pelagic species is more than can be affirmed from any evidence at present forthcoming. The surface-specimens, one of which is represented in fig. 18, *a.b.*, are, as a rule, small and thin-shelled. Such examples have been observed amongst the tow-net organisms collected at six points in the Atlantic, and at seven points in the Pacific, but the number of the specimens collected is comparatively small.

The distribution of the species is best estimated from bottom-dredgings, which have revealed its presence at thirteen Stations in the North Atlantic, at six in the South Atlantic, at sixteen in the South Pacific, and at five in the North Pacific, as well as at one or two points in the Indian Ocean. By far the larger proportion of these lie within the tropics. The most northerly locality recorded is lat. 41° 15′ N. in the North Atlantic; the southern limit appears to be about the latitude of Sydney, 34° 13′ S. in the Pacific. The bottoms range in depth from 7 fathoms to 2675 fathoms.

Pullenia obliquiloculata has not hitherto been observed in the fossil condition.

Sphæroidina, d'Orbigny.

Sphæroidina, d'Orbigny [1826], Bronn, Reuss, Ehrenberg, Costa, Egger, Parker and Jones, Karrer, Seguenza, Carpenter, Schwager, Pourtales, M. Sars, Hantken, Brady, &c.
Sexloculina, Czjzek [1847].
Grammobotrys, pars, Ehrenberg [1854].
Globigerina, pars, Schwager [1866].
Bolbodium, Ehrenberg [1873].

The genus *Sphæroidina* was originally described by d'Orbigny in the "Tableau Méthodique," and a place was assigned to it at the end of the Family Enallostegia, immediately following *Virgulina*. The author subsequently found reason to alter his opinion, and in the "Vienna Basin" memoir it appears amongst the Agathistegia, between the Milioline genera *Triloculina* and *Quinqueloculina*. Prof. Reuss, in his classification of the Foraminifera, published in 1861, gives it a position in his Family Polymorphinidea, between *Robertina* and *Dimorphina*.

The near relationship of the genus to *Globigerina* was first suggested by Dr. Carpenter and his colleagues; and their view, as propounded in the Introduction to the Study of the Foraminifera, is supported not merely by structural analogy, but by many facts which have since been ascertained in connection with the distribution of the two recognised species. The diversity of opinion which has existed as to the affinity of the genus is mainly due to the somewhat obscure external characters of the test, and the slight indication they afford of its internal structure.

The test of *Sphæroidina* is globular or subglobular in contour, and consists of a small number of extremely convex segments, arranged as a short spire. Owing to the embracing character of the chambers and their rapid increase in size, only the final convolution, which is generally composed of three or four segments, is visible externally. Sometimes, however, by a slight obliquity, or one-sided development of the spire, a larger number of chambers are discernible, but even in such cases the plan of growth is not always apparent. The texture of the shell and its condition with respect to perforation are variable features. The aperture is an arched or nearly semicircular opening, often partially closed by a shelly tongue so as to form a crescentic fissure, and is situated close to the inner margin of the final segment.

The geographical distribution of *Sphæroidina* is almost world-wide. It is found at every latitude from the middle of the west coast of Norway to the shores of Prince Edward Island in the Southern Ocean; and its bathymetrical range includes every depth from 30 fathoms to 2600 fathoms. The genus has a pelagic representative in *Sphæroidina dehiscens*, which is a frequent constituent of the surface-fauna of mid-ocean. The earliest appearance of *Sphæroidina*, geologically speaking, is in the Cretaceous period, but it does not become common or widely diffused until the middle of the Tertiary epoch. It is of frequent occurrence in marine deposits of Miocene and Pliocene age.

Sphæroidina bulloides, d'Orbigny (Pl. LXXXIV. figs. 1–7).

Sphæroidina bulloides, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 267, No. 1,—Modèle, No. 65.
„ *austriaca*, Id. 1846, For. Foss. Vien., p. 284, pl. xx. figs. 19–21.
Sexloculina haueri, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 149, pl. xiii. figs. 35–38.
Sphæroidina variabilis, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 88, pl. vii. figs. 61–64.
Grammobotrys parisiensis, Ehrenberg, 1854, Mikrogeologie, pl. xxvii. figs. 30, 31.
Sphæroidina parisiensis, Id. Ibid. pl. xxvii. fig. 34.
„ *gemmula*, Id. Ibid. pl. xxx. fig. 22.
„ *bulloides*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 29, pl. ii. fig. 58.
Bolbodium sphærula, Ehrenberg, 1873, Abhandl. d. k. Akad. Wiss. Berlin [1872], p. 388, pl. iv. fig. 1.

In its typical presentment the test of *Sphæroidina bulloides* is nearly spherical, and is composed of a few extremely convex segments combined so as to form somewhat less than two convolutions of an involute spire. Each segment is considerably larger than its predecessor, and usually only those of the final convolution, three or four in number, are seen on the exterior; but sometimes, owing to the asymmetry of the chambers or their more or less oblique setting, the earlier segments are visible on one side of the shell. The shell is quite smooth externally and is stoutly built, having an average thickness of about $\frac{1}{500}$th inch. It often presents a laminated structure, as shown in the section (fig. 5), owing to the extension of the walls of the later chambers over those previously formed. The pseudopodial perforations are comparatively minute; they are seldom visible externally and never conspicuous, but in section they appear as tubular canals, the larger of which scarcely exceed $\frac{1}{10,000}$th inch (0·0025 mm.) diameter.

With reference to the nomenclature of the species,—the term *Sphæroidina bulloides* was originally applied by d'Orbigny, both to recent specimens obtained from the shores of the Adriatic and to similar shells from the later Tertiaries of Italy, and the distinctive characters were exemplified in one of the Models of his well-known series. Nevertheless, in the "Vienna Basin" monograph certain Miocene fossils, the figures and description of which correspond in every particular with the Model in question, are introduced under the name *Sphæroidina austriaca*, and this appellation has been commonly adopted, at any rate for fossil specimens, by subsequent writers. It is impossible to recognise the two forms as zoologically distinct; indeed the entire list of "species" enumerated in the foregoing synonymy does not collectively embrace a much wider range of morphological characters than is represented by the group of figures on Pl. LXXXIV.

Sphæroidina bulloides inhabits an extensive geographical area, and the limits of its bathymetrical distribution are correspondingly wide. So far as at present known it is not a pelagic species. It has been found on the western shores of Norway, the British Islands, Belgium, and France; in the Mediterranean, the Adriatic, and the Red Sea. It occurs at twenty-three Stations (Challenger and "Porcupine") in the North Atlantic, the depths varying from 85 to 1750 fathoms; at six Challenger Stations in the South Atlantic, 420 to 2350 fathoms; at fourteen in the South Pacific, 37 to 1375 fathoms; at four in the North Pacific, 95 to 2050 fathoms; at two in the Southern Ocean, 1570 fathoms and 2600 fathoms respectively; and it has also been taken in the Indian Ocean.

The earliest known appearance of the species as a fossil, is in the Chalk of Meudon and of the Island of Rügen (Ehrenberg); and it has been recorded under one name or other from the lower *Clavulina-szabói* formation of Hungary, and the Priabona Beds of North Italy (Hantken); the Septaria-clays of Germany (Reuss, Schlicht); from various Miocene deposits in Austria (d'Orbigny, Czjzek, Reuss, &c.), and Lower Bavaria (Egger); and from the Pliocene of Italy (d'Orbigny, Costa, Jones and Parker, &c.), of the south-east of Spain (Jones and Parker), and of the Nicobar Islands (Schwager).

Sphæroidina dehiscens, Parker and Jones (Pl. LXXXIV. figs. 8–11).

Sphæroidina dehiscens, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 369, pl. xix. fig. 5, *a.b.*
Globigerina seminulina, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 256, pl. vii. fig. 112.
Sphæroidina dehiscens, Pourtales, 1867, Bull. Mus. Comp. Zool. Camb. (1867), p. 107.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix. p. 295.

Sphæroidina dehiscens bears a general similarity to its congener *Sphæroidina bulloides*, not only in the contour of the shell, but in the number of chambers, their individual form, and their mode of arrangement. The walls, however, are thick and coarsely perforated, and more or less reticulated externally; and the chambers are separated by deep irregular sutural fissures, which are either continuous, or closed in places by the approximation of their somewhat jagged edges. The appearance of the test is aptly characterised by the specific name, which suggests its resemblance to the pericarp of a dehiscent fruit in process of opening. The shell-wall frequently attains a thickness of $\frac{1}{300}$th inch (0·085 mm.), or nearly double that observed in average specimens of *Sphæroidina bulloides;* and the pore-canals often have a diameter of $\frac{1}{2500}$th inch (0·01 mm.).

Judging from bottom-specimens, *Sphæroidina dehiscens* is a widely diffused species. It is common in the tropical and subtropical regions of the Atlantic, and stray examples have been found as far north as the British shores. The Challenger dredgings furnish specimens from nine Stations in the North Atlantic and from eight in the South Atlantic; from twenty-three Stations in the South Pacific, and from four in the North Pacific. Nevertheless, as a pelagic organism, it is comparatively rare in the tow-net gatherings

made during the voyage; and, setting aside a single broken shell from the South Pacific, I have only detected surface-specimens in the mountings from four localities, all of which are in the Atlantic, within a few degrees of the equator.

Sphæroidina dehiscens was obtained by Schwager from the Pliocene deposits of Kar Nicobar, and this appears to be the only record of its occurrence in the fossil state.

Candeina, d'Orbigny.

Candeina, d'Orbigny [1839], Carpenter, Norman, Brady.

The genus *Candeina* was founded by d'Orbigny upon specimens obtained from shore-sands collected in the West Indies by M. Ferdinand de Candé.

The test in its typical condition assumes the form of a somewhat elevated turbinoid spire, composed of subglobular segments; and its distinctive peculiarity is furnished by the aperture, which consists of a number of pores arranged in lines along the sutural depressions of both the superior and inferior surface. D'Orbigny appends to his description of the genus the following note indicating the points in which it differs from the allied types of Foraminifera:—"Par ses loges globuleuses sphériques, ce genre a du rapport avec les *Globigerina;* néanmoins nous avons dû l'en séparer en raison de sa contexture vitreuse, brillante, non rugueuse et perforée, de sa spire plus allongée, plus régulière, et surtout d'un caractère unique jusqu'à présent parmi les coquilles turbinées vivantes, caractère qui consiste dans le grand nombre d'ouvertures de sa dernière loge."[1]

Dr. Carpenter appears to have based his account of the genus upon d'Orbigny's figures rather than on the study of actual specimens; and, misled by the superficial resemblance to some varieties of *Verneuilina,* has treated it as a sub-genus of *Textularia,* at the same time questioning "whether its distinctive modification is of more than varietal importance."[2]

The minuter characters of the type will be best considered in connection with the single species, *Candeina nitida.*

Candeina nitida, d'Orbigny (Pl. LXXXII. figs. 13–20).

Candeina nitida, d'Orbigny, 1839, Foram. Cuba, p. 111, pl. ii. figs. 27, 28 ("Modèle, No. 105.")
" " Id. 1846, For. Foss. Vien., p. 193, pl. xxi. fig. 28.
" " Norman, 1876, Proc. Roy. Soc., vol. xxv. p. 215.
" " Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 77.

The test of *Candeina nitida* is thus described by the discoverer of the species:—"*Coquille* très élevée, conique, lisse, brillante, translucide. *Spire* saillante, conique, composée de cinq tours et formée de treize ou quatorze loges. *Loges* sphériques très séparées, au nombre de trois à chaque tour, toujours régulièrement placées les unes

[1] Foram. Cuba (French ed.), p. 108.

[2] Introd. Foram., p. 192.

au dessus des autres, de manière à représenter, dans leur ensemble, trois suites verticales de loges croissant également des premières aux dernières. *Ouverture.* Nous n'avons remarqué aucune ouverture centrale; mais, sur le retour de la spire, la dernière loge est percée, sur le bord, de six à sept petites ouvertures. *Couleur* blanche, transparente. *Dimensions.* Diamètre $\frac{1}{2}$ millim." [1]

With considerable allowance for the variability of individuals, these characters express with tolerable accuracy the salient features of the organism, so far at anyrate as concerns the external conformation of the test; but they require amendment in several minor points. It is quite true that the test has no general aperture, but the sutural orifices are much more numerous than stated by the author; and they are by no means confined to the margin of the latest chamber, or even of the final convolution, but usually appear also, though in smaller numbers, at the borders of the earlier segments. The diameter of fully grown specimens is often as much as $\frac{1}{37}$th inch (0·68 mm.).

The texture of the shell resembles that of *Sphæroidina bulloides;* it is sometimes transparent and pearly white, but quite as frequently slightly tinged with brown. The walls are excessively thin, averaging less than one-sixth of the thickness of those of the last-named species.[2] The surface of the shell is smooth and polished, and under a low magnifying power appears imperforate; but, when examined under favourable conditions with a lens magnifying 500 diameters or upwards, the pores may be distinctly made out, and they appear to be of very similar size to those of *Pullenia sphæroides,* that is to say, probably not more than $\frac{1}{25,000}$th inch (0·001 mm.) in diameter.

Anomalous specimens, such as that represented by fig. 19, corresponding in form to some of the irregular modifications of *Globigerina* and *Pullenia*, are not unfrequent.

Candeina nitida occurs amongst the surface organisms in the Challenger tow-net gatherings from four localities, two in the South Atlantic and two in the North Pacific. The pelagic specimens are very rare, only one or two from each point; they are much smaller than the dredged shells, and delicately thin and transparent. An average example is portrayed in fig. 13.

Bottom specimens show that the species has a wide area of distribution. It was obtained by the Rev. A. M. Norman from one of the "Valorous" dredgings in the North Atlantic at about the latitude of the north of Ireland (lat. 55° 10′ N.), and this, so far as is at present known, is its northern limit. It occurs at one Challenger Station south of the Canaries, and was found by d'Orbigny in shore-sands from Cuba and Jamaica. In the South Atlantic it is much more generally diffused, having been met with at six Stations, and often in considerable abundance; in the South Pacific it occurs at five Stations and in the North Pacific at one.

[1] Foram. Cuba (French ed.), p. 108.

[2] The thickest portion of a specimen of *Candeina nitida*, the wall of the final chamber, measured $\frac{1}{3000}$th inch (0·008 mm.); another part of the same shell was only $\frac{1}{5000}$th inch (0·005 mm.) in thickness. Specimens of *Sphæroidina bulloides*, with which they were compared, gave a thickness of rather less than $\frac{1}{500}$th inch (0·05 mm.).

The question naturally arises, whether or no *Candeina* is essentially a free-swimming type in the same sense as *Globigerina* or *Hastigerina;* and except on the hypothesis that an organism which is sometimes pelagic is necessarily always pelagic, for which there is no reasonable ground, the evidence is not sufficient to supply a positive answer. *Hastigerina*, the genus to which *Candeina* bears most resemblance in the extreme tenuity of the shell-wall, is comparatively common in surface gatherings, whilst its shells are very rare in the bottom ooze of the same areas, and are invariably much broken; and it is difficult to see why there should be any discrepancy in the proportionate numbers of surface and bottom specimens if the life conditions are identical. On the other hand, it is worth mentioning that *Candeina nitida* sometimes occurs in dredged material which is almost entirely composed of organisms of pelagic habit.

There is no record of the occurrence of the species in the fossil state.

Family IX. ROTALIDÆ.

The Foraminifera of the Family Rotalidæ form a complicated and difficult group, assuming characters so diverse in their extreme modifications, that there is scarcely a single feature, beyond the calcareous shell and its hyaline and perforate texture, that is common to the whole of the members. There are nevertheless certain peculiarities of structure and modes of growth that may be regarded as distinctively "Rotaline"; and, though these are not common to the entire series, the exceptional cases are comparatively few, and the connection of the aberrant forms with those of more typical character is for the most part sufficiently obvious. Thus, with the rare exceptions alluded to, the test is always polythalamous, and in its early stages, if not throughout, the chambers are spirally arranged; and, typically, the spire is inequilateral, that is to say, the convolutions are more embracing on one side than the other. It is needless at the outset to dwell upon these and other characters of more or less general application, which will be best understood and their comparative significance best determined when considered with relation to the consecutive generic types.

The simplest of all spiral and perforate Foraminifera are comprised in the genus *Spirillina*, the test of which consists typically of an undivided tube coiled regularly upon itself. Usually the spire is symmetrical and complanate; but in some cases the coils are more or less oblique, foreshadowing the inequilateral construction of the true *Rotalinæ*, and in others the successive convolutions are superimposed more or less vertically, so as to produce a conical test. The conical *Spirillinæ* are scarcely distinguishable from the feebler varieties of *Patellina;* and the relationship of the genus to the Rotaline group is further evidenced by the tendency of the weaker modifications of *Pulvinulina* to assume Spirilline characters.

Turning now to the Sub-family ROTALINÆ :—As may be inferred from what has been already stated, *Patellina* exhibits the nearest approach to the Spirilline simplicity of structure. In certain cases the test of *Patellina* consists partially or entirely of a non-septate or imperfectly septate spiral tube, the coils of which are disposed so as to form a cone ; but in more typical specimens, and in all the larger species, the outer layer is constructed of distinct spirally-arranged or annular segments, subdivided into chamberlets, and the centre of the cone is filled either with a deposit of clear shell-substance or with a mass of closely-packed minute chambers. The allied genus *Cymbalopora* presents a structure in many respects similar, the conical varieties being composed of small segments, arranged spirally at first but subsequently in annuli, each segment communicating with a central or umbilical hollow, the weaker varieties assuming a depressed or irregularly spreading contour like the true *Planorbulinæ*.

The genera *Discorbina*, *Planorbulina*, *Pulvinulina*, and *Rotalia*, which, so far as number of species or abundance of individuals is concerned, constitute the bulk of the Family, form four parallel groups, the mutual relationship of which is best understood by a comparison of their collateral species. The closest affinity in every case subsists between the different members of the same series, and the most correct view of each genus is obtained by grouping the species round a central type, of which they are regarded as the successive modifications. The types selected for the purpose by Profs. Parker and Jones, to whose researches we are largely indebted for our present knowledge of this portion of the subject, are *Discorbina turbo*, d'Orb., sp.; *Planorbulina farcta*, F. and M., sp.; *Pulvinulina repanda*, F. and M., sp.; and *Rotalia beccarii*, Linné, sp. The degree of resemblance between the corresponding varieties or "isomorphs" of the parallel series varies greatly in different cases. In some it is an agreement in little else than external contour, whilst in others the likeness is sufficient to be a source of difficulty in determining the generic position of specimens; but it is seldom that the true relationship is not betrayed by the presence, to a greater or less extent, of some of the conspicuous characters of the typical form.

What is known as a "Rotaline" or "Rotaliform" shell is one consisting of numerous segments arranged in an inequilateral spire, the whole of the segments being visible on one side of the test, those of the outermost convolution only on the other. In some cases the superior[1] or spiral face is convex or conical and the inferior flat; in others the two

[1] The terms "superior" and "inferior," as applied to the ROTALIDÆ, are used in the sense defined by Williamson, as follows :—"The primordial segment usually occupies the apex of each trochoid form ; and to the lateral surface on which this segment appears may be assigned the term *superior ;* whilst the opposite one, or that in the direction of which the animal is extending its growth, may be designated the *inferior* lateral surface. There are a few exceptional cases, as, for example, the British *Truncatulinæ*, and the foreign genus *Faujasina* [*Rotalia schroeteriana*], which simply represent an equilateral or nautiloid shell cut in half, the intersection being in the plane of the centre of the primordial segment. Hence the surface in the centre of which the primordial segment appears instead of being conical, is flat ; whilst the opposite one, in which the animal is extending itself, is more or less conical ; the former being that by which the animal attaches itself to other bodies. Notwithstanding the apparent incongruity of applying the terms

sides are equally or unequally convex; in others, again, both are complanate or slightly concave; and in some the superior face is flat and the inferior convex. These conditions are variably represented in the four genera under consideration.

The annexed Table, in which a number of species from each generic group are cast into parallel columns, is intended to illustrate broadly the isomorphism which has been described. It serves also to show the general contour of test most prevalent in the different genera. For example, it indicates that *Discorbina* is rich in forms with convex or conical superior face, whilst it has but few that are convex and none that are conical on the inferior side, and no evolute or wild-growing adherent species; that *Planorbulina*, on the other hand, has scarcely any varieties with the superior side convex or conical; that *Pulvinulina* has nothing corresponding to the complanate or bilaterally symmetrical modifications of the other genera; and that *Rotalia*, with its fewer species, is almost entirely wanting in evolute, adherent, and wild-growing forms. Two lines have been added to the Table to show that the parallelism extends to other particulars, such as the external limbation of the sutures, and the extension of the margin of the test into radial points or spines. The scheme might be extended in many ways. An additional column might be assigned to the genus *Cymbalopora*, though the number of species is comparatively small and their range of variation correspondingly limited, and an interesting collateral series might also be drawn from the genus *Globigerina;* but the object of the Table is sufficiently attained without further expansion.

It would be manifestly impossible to frame zoological descriptions based upon the conspicuous features of the test that would avail to separate genera constructed on lines so nearly identical; and it is from characters other than those derived from the form and mode of combination of the segments that means of distinction are to be sought. Such characters do exist, though they are often ill-defined and always variable. For example, the genus *Discorbina* may pretty constantly be recognised by the presence, in one form or other, of certain projections from the inner margins of the segments on the inferior side, known as "umbilical lobes," more fully described on a later page; or, when these are not apparent, by a surface-ornament of radiating costæ or lines of closely-set granules. The *Planorbulinæ*, of all sections of the group, are known by their coarsely porous thick-walled tests, and a tendency to produce lipped apertures, the orifice of the

superior to a surface which in the living creature is so obviously *inferior*, I have not thought it desirable to disturb the general application of these terms to meet so exceptional a case."—Brit. Rec. Foram., Introd., pp. xvi, xvii.

This rule is by no means free from objection; but perhaps it would be impossible to devise one in all respects satisfactory. The employment of the terms in a manner equally available for the elongate spiral types, such as *Bulimina* and *Textularia*, and moniliform shells like the *Nodosariæ*, would have been in many ways preferable. These latter forms are always represented pictorially with the primordial segment at the base and the growing-point at the summit; and by Williamson and others the terms *posterior* and *anterior* are employed for them respectively; so that *posterior* becomes the equivalent of *superior* and *anterior* of *inferior*, which is somewhat anomalous. In a large number of cases the words *spiral* and *umbilical* may properly be used, as an alternative, for the two aspects of the Rotaline shell, but they are not quite uniformly applicable.

Table illustrating the Isomorphism of some of the chief varieties of ROTALINÆ.

	Discorbina.	Planorbulina.	Pulvinulina.	Rotalia.
Superior face conical, inferior flat.	*D. tabernacularis*, Brady.	*T. rosea*, d'Orb.	*P. procera*, Brady.	...
	D. turbo, d'Orb.	*T. conica*, Roemer (?)	*P. trochus*, Münst.	*R. nitida*, Will.
Superior face more or less convex, inferior flat.	*D. globularis*, d'Orb.	...	...	...
	D. parisiensis, d'Orb.	*T. schloenbachi*, Rss.	*P. hemisphærica*, Rss.	...
	D. opercularis, d'Orb.	...	...	...
Thin, outspread, one or both faces slightly convex.	*D. cora*, d'Orb.	*T. wuellerstorfi*, Schw.	*P. concava*, Reuss.	...
	...	*T. ungeriana*, d'Orb.	*P. menardii*, d'Orb.	...
Thick, both faces convex.	*D. nana*, Reuss.	*T. simplex*, d'Orb.	*P. punctulata*, d'Orb.	*R. beccarii*, Linn.
	D. turris, Karrer.	*T. haidingerii*, d'Orb.	*P. repanda*, F. & M.	*R. broeckhiana*, Kar.
Complanate, more or less evolute, margin square.	*D. biconcava*, P. & J.	*A. ariminensis*, d'Orb.	...	...
Complanate, more or less evolute, margin round.	*D. rugosa*, d'Orb.	*A. ammonoides*, Rss.	...	*R. ammoniformis*, d'Orb.
	D. polystomelloides, P. & J.	*A. grosscrugosa*, Gümb.	...	...
Superior face flat, inferior more or less convex.	*D. saulcii*, d'Orb.	*T. akneriana*, d'Orb.	*P. boueana*, d'Orb.	*R. exsculpta*, Rss.
	D. bertheloti, d'Orb. (?)	*T. lobatula*, W. & J.	*P. crassa*, d'Orb.	*R. orbicularis*, d'Orb.
Superior face flat, inferior highly convex or conical.	...	*T. refulgens*, Mont.	*P. micheliniana*, d'Orb.	*R. soldanii*, d'Orb.
Thin, evolute, adherent.	...	*P. mediterranensis*, d'Orb.	*P. vermiculata*, d'Orb.	...
Wild-growing, adherent.	...	*P. retinaculata*, P. & J.	*P. dispansa*, Brady.	...
Limbate sutures.	*D. binkhorsti*, Rss.	*A. calymene*, Gümb.	*P. caracolla*, Roem.	*R. ornata*, d'Orb.
	D. valvulata, d'Orb.	*T. præcincta*, Karrer.	*P. berthelotiana*, d'Orb.	*R. annectens*, P. & J.
Stellate or spinous margin.	*D. stellata*, Rss. (?)	*A. polymorpha*, Costa.	*P. spinimargo*, Reuss.	*R. calcar*, d'Orb.
	D. imperatoria, d'Orb. (?)	...	...	*R. pulchella*, d'Orb.

Rotaliform or lenticular varieties being placed at or near the peripheral margin. The *Pulvinulinæ* are always finely porous and the test (with only two or three exceptional species) is almost invariably regularly Rotaline; the sutures are often limbate externally, but the surface hardly ever otherwise ornamented. The genus *Rotalia* attains a somewhat higher type of structure than its allies, the well-characterised forms having double septa and an interseptal skeleton, the latter often traversed by a more or less complex system of canals; whilst the smaller varieties, which have no supplemental skeleton, betray their relationship by the thickened and granulose edges of the sutures on the inferior side.

The connection of *Rupertia* and *Carpenteria* with the foregoing genera, through the subconical *Planorbulinæ*, is easily traced. The former in its early stage has a *Truncatulina*-like shell, which grows adherent by its superior face; and the subsequent whorls, which are of nearly uniform diameter, are superimposed vertically instead of peripherally, so as to form a columnar test, the aperture of which is at the inner margin of the terminal segment. The relationship of *Carpenteria* is best understood from *Carpentaria monticularis*. In the young condition the test, which is scarcely distinguishable from that of *Truncatulina refulgens*, consists of a depressed cone growing attached by its superior lateral surface; the aperture, however, at a very early stage becomes apical or nearly so, and the later chambers assume an elongated and irregular contour, spreading radially. Some species of *Carpenteria* exhibit double septal walls and a rudimentary canal system; but this is not a constant or even a usual feature.

Calcarina differs from *Rotalia* chiefly in the excessive development of the supplemental skeleton, which not only fills the umbilical cavity of the test, but forms the peripheral spines that characterise the genus.

The Sub-family Tinoporinæ embraces a number of types, the Rotaline affinity of which is not quite so apparent. The test of *Tinoporus* consists of a central plano-spiral disk, with chamberlets piled on either side in more or less regular tiers; and it is furnished with a supplemental skeleton, which manifests itself externally in radial spines like those of *Calcarina*. The closely allied *Gypsina* has likewise a spiral nucleus, though of minute dimensions, with chamberlets clustered around it either in one plane or more or less equally on all sides. Neither of these types present any general aperture, external communication being maintained by the coarse perforations of the chamber-walls. *Aphrosina*, on the other hand, has a similar test, of irregular convex shape and spreading habit, with numerous marginal orifices.

The somewhat aberrant genus *Polytrema* displays intermediate characters. Its affinity to the Tinoporinæ is indicated by its numerous minute chambers disposed in more or less regular layers, and by the absence, in the encrusting varieties, of any general aperture; whilst the monticular apertural processes of the arborescent forms suggest their near relationship to *Carpenteria*.

By some recent authors the genus *Cymbalopora* has been placed amongst the Globi-

GERININÆ, and a good deal might be said in favour of this view; but on the whole its most natural position appears to be in the Rotaline series, in the immediate vicinity either of *Patellina* or of *Planorbulina*. Again, the genus *Rotalia* has been removed by Moebius from the other Rotaline genera, and classed with *Operculina*, *Heterostegina*, and their allies, on account of the complicated canal system with which the more highly developed species are endowed. It must, however, be borne in mind that it is only a portion of the genus that is so characterised; that the structure of some of the smaller species is as simple as the feeblest *Discorbinæ*, and that of the majority only so far advanced as to have double septal-walls; whilst, on the other hand, certain allied genera, such as *Tinoporus* and *Carpenteria*, exhibit to a greater or less degree the same tendency to produce an interseptal skeleton with its almost invariable accompaniment of ramifying canals. The presence or absence of a canal system, though important from a structural point of view, is not a character upon which a primary distinction of this sort can be founded.

Sub-family I. Spirillininæ.

Spirillina, Ehrenberg.

Spirillina, Ehrenberg [1841], Parker and Jones, Williamson, Carpenter, Gümbel, Brady, Kübler and Zwingli, Terquem, Siddall, Berthelin, Moebius.
Operculina, pars, Reuss [1849].
Cornuspira, pars, Schultze [1854].
Cyclolina, Egger [1857].

The essential characters of the genus *Spirillina* may be summed up in few words. The test consists typically of a non-septate tube coiled symmetrically on itself on one plane; the walls are hyaline and perforate, and the open end of the tube serves as the aperture. The deviations from the normal plan of growth are few and insignificant, and seldom amount to more than a certain degree of asymmetry in the form and disposition of the coils. The shell is typically free, in rare instances parasitic. The minor characters on which the specific or varietal subdivision of the genus is founded are derived mainly from the sectional contour of the tube and the condition of the exterior of the test, with respect to surface-ornament, sutural limbation, and the like.

The genus *Spirillina* is isomorphous with *Cornuspira* and *Ammodiscus*, the three types occupying analogous positions in the calcareous and perforate, the calcareous and imperforate, and the arenaceous groups of Foraminifera.

The *Spirillinæ* are for the most part of minute dimensions. They find a home in every part of the world, preferring comparatively shallow, muddy sea-bottoms. They are seldom met with in the fossil state; nor, as far as at present known, do they occur in older formations than those of the Miocene period.

Spirillina vivipara, Ehrenberg (Pl. LXXXV. figs. 1–5).

Spirillina vivipara, Ehrenberg, 1841, Abhandl. k. Akad. Wiss. Berlin, p. 442, pl. iii. fig. 41.
Operculina punctata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, vol. i. p. 370, pl. xlvi. fig. 21.
Cornuspira perforata, Schultze, 1854, Organ. Polythal., p. 41, pl. ii. fig. 22.
Spirillina vivipara, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 284, pl. xi. fig. 46.
Cyclolina impressa, Egger, 1857, Neues Jahrb. für Min. &c., p. 304, pl. x. figs. 7, 8.
Spirillina perforata, Williamson, 1858, Rec. For. Gt. Br., p. 92, pl. vii. fig. 202.
„ *vivipara*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 397, pl. xv. fig. 28.
„ „ Moebius, 1880, Foram. von Mauritius, p. 88, pl. viii. figs. 1, 2.

Spirillina vivipara is the simplest form of a very simple genus. The test is free, or in rare cases adherent; and consists of a tube coiled on itself on one plane. The tube is either nearly round in section or compressed, and the convolutions are often slightly embracing; the earlier coils are generally comparatively narrow, the later ones broader and of nearly uniform width; the walls are conspicuously perforated, and the aperture is formed by the unconstricted end of the tubular cavity. The lateral faces of the test are either flat, as in fig. 4, or concave, as in figs. 1–3; and the peripheral edge is rounded. The spiral suture is sometimes deeply excavated on the exterior, as in fig. 1; sometimes nearly flush, as in fig. 4, according to the more or less embracing contour of the tube. The diameter of the shell varies from about $\frac{1}{60}$th inch (0·42 mm.) to less than half that size.

Spirillina vivipara is found in almost every part of the world, from the furthest known point of the Arctic Sea, lat. 83° 19′ N., to the shores of Kerguelen Island; the area of distribution embracing the North and South Atlantic, the North and South Pacific, the Indian and the Southern Ocean, the Mediterranean, and the Red Sea. It most affects muddy bottoms of less than 150 fathoms, but it is occasionally met with at greater depths, 620 fathoms being the deepest of the Challenger Stations at which it has been observed.

In the fossil condition it is comparatively rare, unless, owing to its diminutive size, it has been overlooked; nevertheless it has been observed in the Miocene of the Vienna Basin (Reuss), and of Lower Bavaria (Egger); and in the Post-tertiary clays of the north-west of Ireland (Wright).

Spirillina obconica, H. B. Brady (Pl. LXXXV. figs. 6, 7).

Spirillina obconica, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 279, pl. viii. fig. 27, *a.b.*

Test free, in the form of a depressed cone with elliptical base; superior face convex, inferior concave, peripheral edge rounded; composed of from four to eight convolutions of a subcylindrical tube, swollen at its commencement, but subsequently of even diameter,

the whole of the convolutions being visible on both sides of the test. Shell-wall very thin; perforations apparently confined to the superior surface, sometimes arranged in a more or less regular single row, sometimes obscure. Longer diameter about $\frac{1}{80}$th inch (0·3 mm.).

Spirillina obconica occurs with some of its congeners off Prince Edward Island, 50 to 150 fathoms; in Christmas Harbour, Kerguelen Island, 120 fathoms; and in Nares Harbour, Admiralty Islands, 17 fathoms.

Spirillina inæqualis, H. B. Brady (Pl. LXXXV. figs. 8–11).

Spirillina inæqualis, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 278, pl. viii. fig. 25, *a.b.*

Test free or adherent, discoidal, relatively thick; consisting of four or five convolutions; inferior (adherent) surface flat, broader than the superior; superior face concave, or excavated at the umbilicus; periphery oblique, margin acute or subcarinate. Shell-wall coarsely perforated; surface uneven, often decked with slightly raised bosses or tubercles. Diameter $\frac{1}{80}$th inch (0·3 mm.).

Compared with the typical *Spirillina vivipara* this species presents, as a rule, a somewhat smaller and thicker shell, with sloping instead of rounded peripheral wall. The form of the shell and the appearance of the basal surface suggest a parasitic habit; and from the circumstances under which it has been found it seems probable that it grows attached to shreds of algæ or similar soft organic bodies. The extension of the margin of the inferior side is mainly due to the increased substance of the shell-wall, which on the upper face remains thin, perforate, and delicately transparent.

Spirillina inæqualis has been observed in shallow-water dredgings from several of the island groups of the Pacific, namely:—off Honolulu, Sandwich Islands, 40 fathoms; Nares Harbour, Admiralty Islands, 17 fathoms; off Tongatabu, Friendly Islands, 18 fathoms; off Fiji Islands, 12 fathoms; and off Raine Island, Torres Strait, 155 fathoms.

Spirillina tuberculata, H. B. Brady (Pl. LXXXV. figs. 12–16).

Spirillina tuberculata, Brady, 1878 (in Siddall's—Foraminifera of the Dee), Proc. Chester Soc. Nat. Sci., pt. ii. p. 50.

„ „ Id. 1879, Quart. Journ. Micr. Sci., vol. xix. p. 279, pl. viii. fig. 28, *a.b.*

Test free, planospiral, seldom quite symmetrically coiled; peripheral edge rounded or (in small specimens) somewhat square. Surface more or less covered with exogenous deposit, which often fills the sutural depressions, except that bounding the final convolution; the exterior of the whole shell beset with well-defined raised tubercles, which are

generally more prominent on one side of the test than on the other. Diameter, $\frac{1}{50}$th to $\frac{1}{25}$th inch (0·5 to 1 mm.).

This form is closely allied to the *Spirillina margaritifera* of Williamson. It may be distinguished by the somewhat embracing contour of the tube, and the nearly complanate sutures, as well as by the exostoses, which, instead of being few in number and arranged in a single row, are scattered in profusion over the whole surface of the test.

The figured specimens are all from Balfour Bay, Kerguelen Island, 20 to 50 fathoms. The species occurs also in Christmas Harbour, Kerguelen, 120 fathoms; in the Sarmiento Channel, west coast of Patagonia, 400 fathoms; off Kandavu, 210 fathoms; off Honolulu, 40 fathoms; and on the shores of Madagascar. Small specimens have also been taken at one or two points on the British coast.

Spirillina limbata, H. B. Brady (Pl. LXXXV. figs. 18–21).

Spirillina limbata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 278, pl. viii. fig. 26, *a.b.*

Test planospiral, thin, equilateral, discoidal; lateral faces flat or only slightly concave; peripheral edge square. Spiral sutural line marked externally by a raised band of shelly deposit; surface otherwise smooth. Diameter, $\frac{1}{60}$th to $\frac{1}{30}$th inch (0·42 to 0·84 mm.).

In *Spirillina limbata* the shell-wall is thicker and the perforations are less conspicuous than in many other varieties of the genus; but the really distinctive characters are the sutural limbation and the square periphery. It is isomorphous with *Cornuspira crassisepta* in the porcellanous group.

The distribution-list of the species embraces altogether thirteen localities, which are apportioned as follows:—one in the North Atlantic, one in the Mediterranean, three in the South Atlantic, one in the Southern Ocean, six in the South Pacific, and one in the North Pacific. One of the South Atlantic Stations has a depth of 1425 fathoms, but with this exception the bathymetrical range is from 6 to 675 fathoms.

Spirillina limbata, var. *denticulata*, nov. (Pl. LXXXV. fig. 17).

External form and general characters of the test resembling those of *Spirillina limbata*; the raised spiral band covering the sutural line furnished with buttress-like teeth, set at regular intervals along its inner margin.

This rather ornate variety occurs off East Moncœur Island, Bass Strait, at a depth of 38 fathoms; and in company with the simply limbate form, off Raine Island, Torres Strait, 155 fathoms, and in Nares Harbour, Admiralty Islands, 17 fathoms.

Spirillina decorata, n. sp. (Pl. LXXXV. figs. 22–25).

Test free, discoidal, bilaterally symmetrical, or nearly so; composed of six or eight convolutions of a somewhat embracing tube. Lateral faces slightly concave, peripheral edge thin and subcarinate; perforations obscure in thick-walled specimens, the surfaces of which become pitted and furrowed; aperture of the adult test somewhat contracted and triangular. Diameter, $\frac{1}{30}$th inch (0·84 mm.) or more.

This form is distinguished from the other species of *Spirillina* by its thin subcarinate periphery. The contour of the test resembles that of *Cornuspira carinata*. As the shell-wall thickens with age, the perforations appear to be gradually filled up, and eventually have the aspect of minute superficial depressions. The surface is often also marked with short transverse furrows, especially near the margin of the coils.

Spirillina decorata affects deeper water than most of its congeners. It has been observed at three points in the North Atlantic,—off the Azores, 1000 fathoms; off the Canaries, 1125 fathoms; and off Culebra Island, 390 fathoms: at one point in the South Atlantic,—off Pernambuco, 675 fathoms: and at three in the South Pacific,—off Raine Island, 155 fathoms; off Booby Island, 6 fathoms; and off Kandavu, 610 fathoms.

Sub-family 2. Rotalinæ.

Patellina, Williamson.

Madreporites, Blumenbach [1805], (*fide* Bronn).
Orbulites, pars, Lamarck [1816], Lamouroux.
Orbitolites, pars, Defrance [1826].
Cyclolina, pars, d'Orbigny [1846].
Orbitolina, d'Orbigny [1852], Bronn, d'Archiac, Gras, Parker and Jones, Carter.
Patellina, Williamson [1858], Carpenter, Parker and Jones, Brady, Alcock, Parfitt, G. M. Dawson, Miller and Vanden Broeck, Robertson, Schulze, Terquem, Siddall, Berthelin, Shone, Wright, Fritsch.
Conulites, Carter [1861].

Broadly speaking, the genus *Patellina* is characterised by a conical or plano-convex test, consisting of an external or "cortical" layer of annular, semiannular, or spirally-arranged chambers, and a central enclosed portion or cavity, occupied either by a deposit of clear shell-substance or by a mass of minute chambers, more or less regularly disposed. The chambers of the outer layer are, as a rule, subdivided into chamberlets, the secondary septa being marked externally by transverse lines. Some of the small and imperfectly developed varieties have undivided chambers, either annular or spiral; and in certain

cases present a structure scarcely distinguishable on the superior face from that of *Spirillina*.[1]

The recent species of *Patellina* are the degenerate representatives of a type which, during the Cretaceous and Nummulitic periods, was exemplified by organisms of comparatively large dimensions and complex structure. The genus still lives in almost every part of the world, though it is nowhere very common; it affects shallow water, but is occasionally met with at depths as great as 500 or 600 fathoms. Its geological distribution commences with the Cretaceous period, and it is a prominent type in the earlier Eocene formations; but in deposits of later Tertiary age it is less frequent, and the specimens are of relatively small size.

Patellina corrugata, Williamson (Pl. LXXXVI. figs. 1–7).

Patellina corrugata, Williamson, 1858, Rec. For. Gt. Br., p. 46, pl. iii. figs. 86–89.
Orbitolina (*Patellina*) *corrugata*, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. vi. p. 30.
Patellina corrugata, Carpenter, 1862, Introd. Foram., p. 230, pl. xiii. figs. 16, 17.

This species has been very completely described, both by Williamson and Carpenter (*loc. cit.*), and little remains to be added beyond a few details relative to its distribution.

Patellina corrugata is not uncommon in the North Atlantic and Arctic Oceans. It was one of the Foraminifera observed in the most northerly sounding made on the Nares North-Polar Expedition, lat. 83° 19′ N., depth 72 fathoms; and has also been taken on the coast of Novaya-Zemlya, 50 to 70 fathoms. It occurs on the western shores of Europe, from the littoral zone down to 450 fathoms, and in the Mediterranean to a depth of 250 fathoms. In the South Atlantic its presence has been noted off Tristan d'Acunha, 100 to 150 fathoms, and off the Falkland Islands, 7 fathoms; in the Southern Ocean at five Stations, 13 fathoms to 150 fathoms, the most southerly being off Heard Island, about lat. 52° S.; in the South Pacific at five Stations, 2 fathoms to 620 fathoms; and in the Indian Ocean at a single point, namely, the harbour of Port Louis, Mauritius.

The species has been obtained by Wright from the Post-tertiary beds of the north-west of Ireland, and by Robertson from those of the west of Scotland; but it has not been identified in older formations.

Patellina campanæformis, n. sp. (Woodcut, fig. 19).

Test free, bell-shaped; superior face highly convex, rounded at the apex; inferior face nearly flat, somewhat depressed at the centre; peripheral edge obtuse, slightly

[1] Any account of the minute organization of the test of *Patellina*, without illustrations from the larger fossil forms, is necessarily incomplete. The reader interested in the subject should consult Carter's memoir on some of the Foraminifera from the Tertiary rocks of Scinde (*Ann. and Mag. Nat. Hist.*, 1861, ser. 3, vol. viii. p. 309), and Carpenter's exhaustive account of the genus (*Introd. Foram.*, 1862, p. 229).

spreading. External layer composed of numerous whorls, consisting chiefly of semiannular chambers, the sutures of which are marked by interrupted lines of clear shell-substance; chamber-cavities simple, not subdivided into chamberlets. Central portion of the test filled with shelly deposit. Diameter, $\frac{1}{130}$th inch (0·2 mm.).

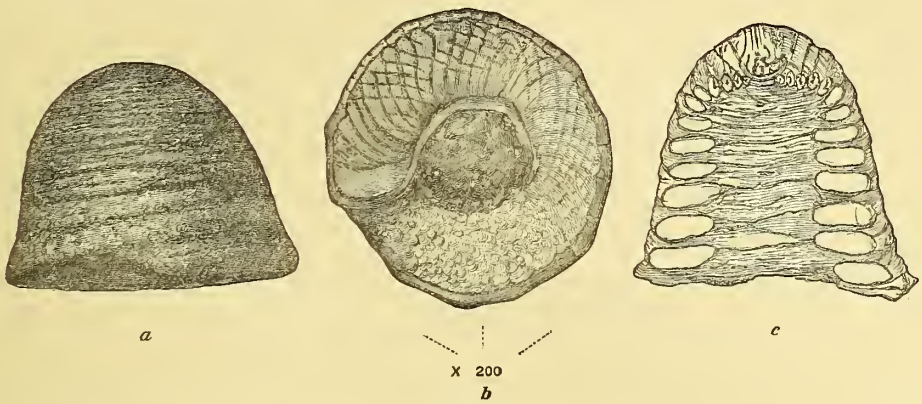

Fig. 19.—*Patellina campanæformis*, n. sp.

a, Lateral aspect; *b*, inferior aspect; *c*, vertical section of the test, viewed by transmitted light. All magnified 200 diameters.

The foregoing is an incomplete, and to some extent provisional, description of an interesting variety of *Patellina*, of which only two examples have as yet been met with. The specimens are exceedingly minute, and their structure is obscured externally by the interrupted limbation or thickening of the septal lines. The chambers are for the most part semiannular, but their arrangement is very indistinct, and one or two of the later whorls appear to form an unbroken spiral. The species is probably closely allied to the *Patellina simplex*[1] of the Grignon Tertiaries, though it does not entirely accord with the characters assigned to that form.

The specimens which form the subject of the present notice were found by Mr. F. W. Millett in dredged material from Station 185, off Raine Island, Torres Strait; depth, 155 fathoms.

Cymbalopora, Hagenow.

Rotalia, pars, d'Orbigny [1826].
Rosalina, pars, d'Orbigny [1839].
Cymbalopora, Hagenow [1850], Carpenter, Parker and Jones, Brady, Moebius.
Rotalina, pars, Pourtales [1867].
Tretomphalus, Moebius [1880].

The distinctive characters of *Cymbalopora* are easy of recognition. The species by which they are exemplified are few in number, but form in some respects almost as diversified a series as the more extensive Rotaline genera.

[1] *See* Parker and Jones, *Ann. and Mag. Nat. Hist.*, ser. 3, vol. vi. p. 29.

The test is Rotaliform; the arrangement of the segments is always spiral to begin with, but frequently annular or irregular during the subsequent stages of growth; and (typically) the individual segments open directly into a central umbilical cavity or vestibule on the inferior side. The successive chambers are not closely contiguous, but are separated by intervals, which appear on the inferior face in the form of radiating depressions or fissures. In certain cases the base of the shell is enveloped by a distended balloon-shaped chamber. The general contour of the test is either conical, convex, complanate, or, as in the variety last referred to, subglobular. The fossil representatives of the type attain a diameter of $\frac{1}{18}$th inch (1·4 mm.), the recent species are scarcely so large.[1]

Broadly speaking, the foregoing are the salient features of the genus, the most distinctive being the independent communication of the individual chambers with the umbilical vestibule, and the separation of the successive chambers by depressions or intervals. The latter peculiarity often produces an appearance of alternation in the arrangement of the adjacent annuli. There are other points of interest, both structural and morphological, but as they are for the most part of specific rather than generic application, their consideration may be deferred.

The genus *Cymbalopora* is classed by Carpenter and his colleagues with the ROTALINÆ, by Bütschli with GLOBIGERININÆ; in point of fact, it has intermediate characters which give it almost equal claim to rank with either group. In many respects it betrays an affinity to *Discorbina*, but its closest relationship is undoubtedly with the Planorbuline series and with *Patellina*; it has therefore been retained in the position assigned to it by the former authors.

The geographical distribution of the genus is limited to tropical and subtropical latitudes. It reaches as far north as Bermuda and the Azores, but in the southern hemisphere it has not been met with south of the Friendly Islands, which are just within the tropical line. Its home is amongst coral-sand, and it is found at every depth from the littoral zone down to 600 or 700 fathoms. The best-known fossil *Cymbaloporæ* are those described by Hagenow, occurring in the Chalk of Maestricht.

Cymbalopora poeyi, d'Orbigny, sp. (Pl. CII. fig. 13, *a.b.c.*).

Rotalia squamosa, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 272, No. 8 (name only).
Rosalina poeyi, Id. 1839, Foram. Cuba, p. 100, pl. iii. figs. 18–20.
,, *squamosa*, Id. Ibid. p. 100, pl. iii. figs. 12–14.
Cymbalopora poeyi, Carpenter, 1862, Introd. Foram., p. 215, pl. xiii. figs. 10–12.
,, ,, Moebius, 1880, Foram. von Mauritius, p. 97, pl. x. figs. 1–5.

Amongst the living representatives of the genus, *Cymbalopora poeyi* is the best

[1] Carpenter alludes to the small dimensions of the recent *Cymbaloporæ* as compared with the fossil forms, and states that "the diameter of ordinary specimens obtained from deep water at the present time does not exceed $\frac{1}{120}$th inch" (Introd. Foram., p. 215). This surely is an error; the typical *Cymbalopora poeyi* is often $\frac{1}{40}$th inch, sometimes nearly $\frac{1}{30}$th inch in diameter; and one of the specimens of *Cymbalopora tabellæformis* now figured measures more than $\frac{1}{22}$nd inch, which is not far short of the dimensions of the Cretaceous species.

embodiment of its typical characters. The test of this species takes the form of a somewhat irregularly built cone with rounded apex, and is composed of a number of narrow segments arranged round a deep umbilical cavity. At the commencement of the shell the mode of growth is spiral, but subsequently the chambers are disposed in more or less distinct annuli, each individual segment having an orifice opening into the umbilical vestibule. The segments of the same annulus are not in close juxtaposition, but are separated by intervals of varying width; these intervals are occupied by the segments of the following layer, and a more or less alternate arrangement of the segments of the successive annuli is thereby established. On the inferior face of the test the intervals appear in the form of symmetrically disposed depressions or radiating fissures. In adult specimens the umbilical recess is generally closed externally by a shelly flap, as seen in fig. 13, *b*. The chamber-walls, so far as visible on the superior aspect of the test, are conspicuously perforated, but on the inferior surface they are smooth, hyaline, and non-porous. Freshly collected shells are usually brown near the apex, the colour gradually disappearing towards the circumference. Fully grown specimens have a diameter of about $\frac{1}{35}$th inch (0·7 mm.).

A variety differing from the typical form in its comparatively depressed contour and the somewhat open arrangement of the segments on the inferior face, is represented by fig. 14, *a–d*. In many localities this modification is more abundant than the type; but whether its immediate relationship is with *Cymbalopora poeyi* or with *Cymbalopora bulloides*, is not very clear.

Parker and Jones are probably correct in assigning the *Rosalina squamosa* of the "Cuba" memoir to the present species; and that form is stated by d'Orbigny to be of parasitic habit, having been found plentifully growing attached to *Fucus* and *Ulva lactuca*, in the West Indies.

Both *Cymbalopora poeyi* and the depressed variety are moderately common amongst the coral-sands of tropical and subtropical seas. Notes have been preserved of the occurrence of one or other at six Stations in the North Atlantic (West Indies, Bermuda, Azores, &c.), the depths ranging from shallow water down to 450 fathoms; at three in the South Atlantic, 350 to 675 fathoms; in the Red Sea, 15 to 20 fathoms; in shore-sands from Madagascar and the Mauritius; in dredged sand from the Seychelle Islands, 8 fathoms; at about twenty localities in the South Pacific, 3 to 610 fathoms; and at four in the North Pacific, 7 to 75 fathoms.

Cymbalopora tabellæformis, n. sp. (Pl. CII. figs. 15–18).

Test depressed, peripheral outline rounded or oval; superior face complanate or nearly so, inferior convex, but with an irregular umbilical cavity or recess; peripheral edge obtuse or rounded. Composed of numerous segments, all of which are visible on the superior face; segments inflated inferiorly, sometimes arranged in more or less regular alternating

annuli, but more frequently disposed without apparent order. Shell-wall coarsely porous; aperture consisting of a number of larger perforations along the lines of the inferior sutural depressions. Colour, in fresh shells, brown near the centre of the superior face, gradually lighter towards the circumference. Diameter, $\frac{1}{25}$th inch (1 mm.).

This is a very distinct variety, bearing something like the same relation to the typical *Cymbalopora poeyi* that *Planorbulina mediterranensis* bears to *Truncatulina lobatula*. It possesses additional interest on account of the character of the aperture, which resembles that of *Candeina nitida*—rows of sutural pores taking the place of the normal umbilical orifices—one of the features, before alluded to, which suggest the near affinity of the genus to the GLOBIGERINIDÆ.

Cymbalopora tabellæformis is, like its congeners, a coral-reef species. The finest specimens hitherto obtained have been from shore-sands collected at Tamatavé, on the east coast of Madagascar, and it has also been found in harbour-mud from Port Louis, Mauritius. It is common in the neighbourhood of the Fiji Islands, at various depths from 12 fathoms to 610 fathoms; and has been noticed in dredged sands from the Ki Islands, 129 fathoms, the Philippine Islands, 95 fathoms, and the Sandwich Islands, 40 fathoms.

Cymbalopora (*Tretomphalus*) *bulloides*, d'Orbigny, sp. (Pl. CII. figs. 7–12).

Rosalina bulloides, d'Orbigny, 1839, Foram. Cuba, p. 104, pl. iii. figs. 2–5.
Cymbalopora bulloides, Carpenter, 1862, Introd. Foram., p. 216.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 80.
Tretomphalus bulloides, Moebius, 1880, Foram. von Mauritius, p. 98, pl. x. figs. 6–9.

The salient feature of *Cymbalopora bulloides* is the large inflated chamber which forms the base of the shell, and constitutes the greater part of its entire bulk. In its earlier stage the test is Rotaliform, the superior side convex, the inferior concave; the segments are arranged in about three convolutions, and, but for a certain irregularity in the disposition of the later whorls, it might in this condition be mistaken for one of the weaker modifications of *Discorbina*. The inferior side of the Rotaliform shell has an umbilical depression, round which the segments are arranged and into which they open, and the intervals between the chambers form radiating fissures. In all these points the initial test resembles the typical *Cymbalopora poeyi;* but the general contour is more outspread and the umbilical recess remains open, not being covered by a shelly flap, as is usual with the latter species. The peripheral margin of the Rotaliform test forms the line of attachment of the large balloon-like chamber which envelops the whole of the inferior side. The distal face of the "balloon" is decked with a number of large Orbuline pores, the margins of which have generally a slight rim or border (fig. 12). Moebius has pointed out that one of the pores near the centre of the disk is furnished with a short tube, pro-

jecting into the cavity of the chamber, and suggests that this constitutes the general aperture of the test. The existence of this entosolenian orifice had been overlooked by previous writers, but I am able to confirm the observations of Moebius in every particular, having seldom failed to trace it except in occasional very small specimens. It often cannot be detected externally, but sometimes it is situated in a little dimple or depression, as shown in the woodcut (fig. 20, *c*); and it may nearly always be distinguished in balsam-mounted specimens when examined by transmitted light. The test attains a diameter of $\frac{1}{45}$th inch (0·56 mm.), or occasionally more.

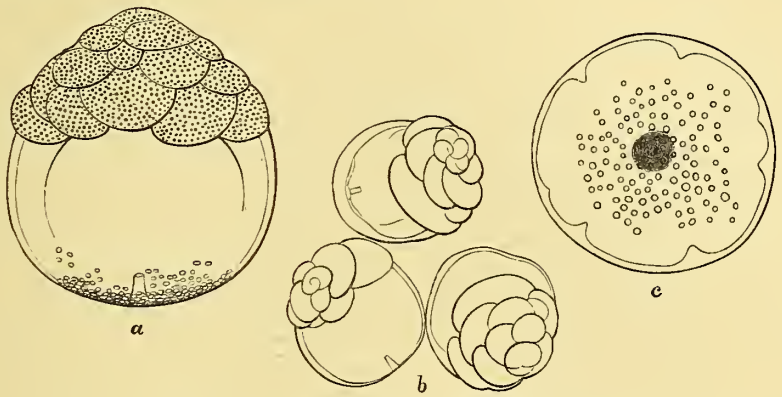

Fig. 20.—*Cymbalopora* (*Tretomphalus*) *bulloides*.

a, Large surface-specimen; *b*, small (young?) specimens from the same gathering; *c*, distal face of the balloon-like chamber, showing the entosolenian orifice, seated in a slight depression. All magnified 60 diameters.

Cymbalopora bulloides has long been known as a bottom Foraminifer, found in company with *Cymbalopora poeyi*, though less common than the latter species; but on the Challenger cruise it was frequently taken in the tow-nets at the surface of the sea, always in shallow areas and in the immediate neighbourhood of coral-reefs. It is somewhat remarkable in connection with the surface-specimens, that the same gathering invariably furnished shells of two distinct sizes, some of them being of the normal adult dimensions (woodcut, fig. 20, *a*), whilst a large number were comparatively minute, their individual diameter being scarcely half that of their associates (fig. *b*). The large shells appeared to be empty, and of intermediate specimens there were few or none. The repeated observation of these facts has led Mr. Murray to question whether *Cymbalopora bulloides* is under all circumstances a pelagic Foraminifer, or whether it is not more probable that it may only be the breeding stage of a bottom-form.[1]

It is clear that the growth of the shell must cease with the formation of the large chamber enveloping the base; so that if the small specimens are the young of the larger ones, as from their structure and mode of occurrence there is reason to believe, they

[1] In every specimen taken from the surface which I examined, the shell was filled with minute monadiform bodies.—J. M.

must either retain their present arrested dimensions, or else rupture the delicate balloon-like envelope, and continue their growth by adding chambers to the spiral or annular series. It appears probable that the latter is what actually takes place, for in bottom dredgings in which the species occurs there are always abundance of shells, the contour and structure of which more nearly resemble the Rotalian portion of *Cymbalopora bulloides* than the normal shell of its ally *Cymbalopora poeyi*. Such specimens are to all appearance living and growing, and sometimes bear traces at the edges of the previous existence of a balloon-like chamber.

Of the close relationship of these forms there can be no doubt, but a question arises as to the degree of importance to be attached to the peculiar characters of *Cymbalopora bulloides*. Moebius treats the inflated final chamber as a generic distinction; but it may be pointed out that similar structures are not unknown in other genera. *Pulvinulina lateralis*, for instance, has a distended final segment with large bordered pores on its distal face, which appears to be analogous, morphologically, to that of the present species (Pl. CVI. fig. 2*b*). Under these circumstances, I have only employed the term *Tretomphalus* provisionally, and in a subordinate sense, for the pelagic variety.

The geographical distribution of *Cymbalopora bulloides* follows that of its congeners, but the number of localities at which it has been found is comparatively small. Surface gatherings were obtained off Zamboanga, Philippine Islands, and at several points in the neighbourhood of the Sandwich Islands. Bottom specimens have been collected in the North Pacific,—off the Honolulu Reefs: in the South Pacific,—off the Admiralty Islands, the New Hebrides, and Raine Island, and at numerous localities around the Fiji group: in the Indian Ocean,—off Mauritius (Moebius), and on the shores of Madagascar: and in the North Atlantic,—from the shore-sands of Cuba and Hayti (d Orbigny), and off Bermuda.

Discorbina, Parker and Jones.

Rotalites, Lamarck [1801], Defrance, Blainville.
Rotalia, pars, Lamarck [1804], d'Orbigny, Münster, Roemer, Michelotti, Parker and Jones, Morris and Quekett.
Discorbis, *Discorbites*, Lamarck [1804], Defrance, Blainville, Berthelin.
Rotulites, Defrance [1824], Blainville.
Rosalina, pars, d'Orbigny [1826], Schultze, Parker and Jones, Reuss.
Anomalina, pars, d'Orbigny [1826], Reuss.
Trochulina, d'Orbigny [1826].
Valvulina, pars, d'Orbigny [1839], Reuss.
Asterigerina, d'Orbigny [1839], Reuss, Egger, Costa, Morris and Quekett, Karrer, Terquem.
Rotalina, pars, Reuss [1845], Williamson, Alcock, Parfitt, Terquem.
Discorbina, Parker and Jones [1862], Carpenter, Brady, Reuss, M. Sars, Karrer, Gümbel, Miller and Vanden Broeck, Schultze, Robertson, Winther, Norman, Hantken, Siddall, Shone, Marsson, Wright, Moebius, Seguenza, Terrigi.

The genus *Discorbina*, as at present understood, was established by Parker and Jones for a group of *Rotalinæ* of which the *Rotalia* (*Trochulina*) *turbo* of d'Orbigny is the central type, and the *Discorbites vesicularis* and *Rotalites trochidiformis* of Lamarck, names of still earlier date, prominent examples. The morphological characters of the group are simple and easily understood, and they do not, on the whole, exhibit quite the same range of variation as is to be met with in the collateral genera *Planorbulina* and *Pulvinulina*.

The test of *Discorbina* is either free or parasitic; it is invariably spiral and typically Rotaliform. Generally speaking, the superior or spiral face is convex or conical, the inferior nearly flat, the whole of the segments being visible in the former aspect, the final convolution only in the latter, and the margin is more or less angular. There are, however, a number of forms, of which *Discorbina rugosa* is an example, the two faces of which are nearly equally convex and the peripheral edge round and lobulated; others, such as *Discorbina biconcava*, that are complanate, both sides being flat or slightly concave and the margin square; and others again, like *Discorbina saulcii*, which are nearly flat on the superior, and convex on the inferior side. The number of convolutions varies from between one and two to four; the total number of segments from seven to twenty or rather more.

The superior aspect of the test does not differ materially from that of the collateral genera of *Rotalinæ*, the distinctive features being more especially connected with the form and arrangement of the segments as seen on the inferior side. On the inferior face, as a rule, only the last convolution is visible; and the aperture of the shell takes the form of a slit or fissure at the umbilical margin of the terminal chamber. The actual opening, however, is seldom visible, being hidden (in typical specimens) by a lobe or tongue projecting from the edge of the segment. These "umbilical lobes" or valves are extremely variable, both as to shape and dimensions. In their fullest development they are separated by marked constrictions from the body of the segments, and form supplementary chambers, which not only mask the umbilicus, but spread radially almost to the periphery of the test, covering-in the septal depressions to a greater or less extent, and alternating with the primary segments, as shown in Pl. LXXXVII. figs. 2 *b*, 4 *b*, and 8 *b*. Such specimens constitute the genus *Asterigerina* of d'Orbigny. But in the majority of cases the supplementary structures are much less conspicuous. Sometimes they form solid masses of shell-substance, filling the umbilicus, and marked externally with exogenous tubercles; on the other hand, the lobes of the successive chambers are often little more than arched projections overhanging the successive orifices; and in certain species they are still more rudimentary, and insufficient collectively to fill or cover the umbilical vestibule. In one form or other these Asterigerine lobes may almost always be recognised, but not only do the several species differ in the degree to which they are developed, but individuals of the same species vary greatly in the same particular.

The shell-wall is hyaline, and often, especially amongst the larger forms, coarsely perforated; but this is by no means an invariable rule. The inferior surface of the test is not unfrequently decorated with slightly raised costæ, or with lines of exogenous granules radiating from the umbilicus; and occasionally the sutures, superior and inferior, are limbate externally; but with these exceptions the genus presents few examples of surface ornament.

In no species of *Discorbina* has any evidence been found of the existence of true interseptal canals, but Carpenter has the following remark concerning *Discorbina rimosa* (and the observation holds equally true of *Discorbina polystomelloides*)—"in this variety we find not only the Asterigerine flaps so much developed as to form a regular series of secondary chambers alternating with the primary, but we also find the exogenous deposit partially bridging over the superficial entrance to the interseptal fissures, dividing it into a row of little passages; and thus is produced a sort of sketch of that intraseptal system of canals which we shall see to be more fully elaborated in *Rotalia*, and to attain its most complete development in *Polystomella*" (Introd. Foram., p. 205).

Parker and Jones have proposed a classification of the genus, under which it is divided into three sections, embracing respectively,—(1) the conical, (2) the vesicular, and (3) the outspread, more or less complanate forms. But the illustrative scheme which they furnish only includes sixteen species, and any attempt to adapt the same arrangement to a much larger series is attended with unsatisfactory results; indeed the authors themselves are careful to explain that "the varieties are so intimately connected one with the other that the classification is little more than suggestive and provisional."

In one or other of its numerous modifications the genus *Discorbina* is found in almost every sea. Its known area of distribution extends from Novaya Zemlya and Davis Strait to the equator, and from the equator to Magellans Strait and Kerguelen Island. It is most common in the shallower zones of the ocean, becoming comparatively scarce at 200 or 300 fathoms, and gradually less frequent down to 1000 fathoms, which is its approximate bathymetrical limit. The earliest appearance of the genus, geologically speaking, is towards the end of the Cretaceous period, and it recurs in almost every marine shallow-water deposit of the Tertiary and Quaternary epochs.

Discorbina turbo, d'Orbigny, sp. (Pl. LXXXVII. fig. 8, *a.b.c.*).

Rotalia (*Trochulina*) *turbo*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 274, No. 29;—Modèle, No. 73.
„ *turbo*, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 306.
Discorbina turbo, Carpenter, 1862, Introd. Foram., p. 204.
„ „ Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 30, pl. ii. fig. 68.

Discorbina turbo, the type of the genus, has a stoutly-built subconical shell, with nearly

flat base and coarsely perforated walls. The valvular flaps form a sort of stellate sutural limbation on the inferior face.

Good examples have been found in the material dredged at four Challenger Stations :— off St. Vincent, Cape de Verde Islands, 11 fathoms (large and well-characterised); off Ascension Island, 420 fathoms (small); off the coast of South America, near Pernambuco, 350 fathoms; and Port Jackson, Australia, 2 to 10 fathoms. I have also specimens from the coral-sands of Bermuda; from Port Stephens, New South Wales; and elsewhere.

Discorbina turbo occurs in the Chalk of Maestricht (Parker and Jones); and it is a prominent species amongst the fossil microzoa of the Eocene formations of Paris.

Discorbina globularis, d'Orbigny, sp. (Pl. LXXXVI. figs. 8, 13).

Rosalina globularis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 271, pl. xiii. figs. 1–4 ;—Modèle, No. 69.
„ *varians*, Schultze, 1854, Organ. Polythal., p. 60, pl. iii. figs. 8–13.
Rotalina semiporata, Egger, 1857, Neues Jahrb. für Min., &c., p. 276, pl. viii. figs. 1–3.
„ *concamerata* (young), Williamson, 1858, Rec. For. Gt. Br., p. 53, pl. iv. figs. 104, 105.
Discorbina turbo, var. *globularis*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
„ „ var. *vesicularis*, subvar. *globularis*, Id., 1865; Phil. Trans., vol. clv. p. 386, pl. xiv. figs. 22, 23.
„ *globularis*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 30, pl. ii. fig. 69.

Discorbina globularis is the commonest and most widely-diffused member of the genus. The figured specimens are not quite typical, the test being seldom so large or so thick-walled, whilst the segments are usually more globular and projecting, and the sutures depressed and without external limbation. Several of the figures referred to in the synonymy are more characteristic of the species. The shell is often found attached to Algæ, Polyzoa, and like objects.

Discorbina globularis is plentiful in the shallower zones of temperate and sub-tropical seas, less frequent within the tropics. Its geographical range extends from about the Arctic Circle (Davis Strait and the coast of Norway), on the north, to Magellans Strait on the south. It is abundant at depths of less than 50 fathoms, and becomes gradually scarcer down to about 450 fathoms, beyond which it has not been obtained.

The species has been recognised in the fossil state as far back as the Eocene deposits of Grignon; and it occurs in many subsequent formations, such as the Miocenes of Lower Bavaria and Southern Italy (Egger, Seguenza), the Pliocene of Italy and of the Island of Rhodes (Seguenza, Terquem), and the Post-tertiaries of the British Islands, Italy, and elsewhere.

Discorbina valvulata, d'Orbigny, sp. (Pl. LXXXVII. figs. 5–7).

Rosalina valvulata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 271, No. 4.
„ „ Id. 1839, Foram. Cuba, p. 103, pl. iii. figs. 21–23.
„ „ Id. 1839, Foram. Canaries, p. 136, No. 28, pl. ii. figs. 19–21.
Discorbina valvulata, Jones and Parker, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 114.

D'Orbigny's figures of *Discorbina valvulata* represent a somewhat thin outspread test, which in point of conformation nearly equally resembles *Discorbina globularis* and *Discorbina rosacea*, but with the septal lines of the superior face marked by broad exogenous bands. The Challenger specimens are more stoutly and compactly built, and in so far are more nearly allied to *Discorbina globularis*. The extreme expression of the typical characters is found in the *Discorbina binkhorsti*[1] of the Maestricht Chalk, which has a much depressed, few-chambered test, with the sutural limbation even more strongly developed.

Discorbina valvulata occurs on the shores of Australia and of the islands of the South Pacific, in Hong Kong Harbour, and amongst the West Indies, and the Canaries,—always in very shallow water.

Discorbina obtusa, d'Orbigny, sp. (Pl. XCI. fig. 9, *a.b.c.*?).

Rosalina obtusa, d'Orbigny, 1846, For. Foss. Vien., p. 179, pl. xi. figs. 4–6.
Discorbina turbo, var. *vesicularis*, subvar. *obtusa*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 386, pl. xiv. figs. 18, 19.

The figured specimen, though agreeing well as to contour and segmentation with *Discorbina obtusa*, is by no means typical, the walls being as fine and smooth in texture and as minutely foraminated as those of a *Pulvinulina*. This may be a matter depending more or less upon habitat, as the shell from which the drawing was made came from a warmer region and somewhat greater depth than generally affected by the species.

Such forms occur off Ascension Island, 420 fathoms. Parker and Jones state that the species is tolerably plentiful off the Hunde Islands, Davis Strait, at from 28 to 70 fathoms, commonest at the greater depths. Their figures also represent rather finely porous shells; and I have similar examples from the west coast of Scotland.

D'Orbigny's specimens were Miocene fossils from Nussdorf, near Vienna.

Discorbina rosacea, d'Orbigny, sp. (Pl. LXXXVII. figs. 1, 4).

Rotalia rosacea, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 273, No. 15;—Modèle, No. 39.
Asterigerina planorbis, Id. 1846, For. Foss. Vien., p. 205, pl. xi. figs. 1–3.
„ *rosacea*, Id. 1852, Prodrome de Paléont., vol. iii. p. 158, No. 2952.
Rotalina mamilla, Williamson, 1858, Rec. For. Gt. Br., p. 54, pl. iv. figs. 109–111.
Discorbina turbo, var. *rosacea*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 385, pl. xvi. fig. 28, *a.b.*
„ *rosacea*, Parker, Jones, and Brady, 1865, Ann and Mag. Nat. Hist., ser. 3, vol. xvi. p. 25, pl. ii. fig. 71.

[1] *Rosalina binkhorsti*, Reuss, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 317, pl. ii. fig. 3.

That the peculiar features upon which the genus *Asterigerina* was originally founded prevail to a greater or less extent throughout the larger group of Rotalines which constitute the *Discorbinæ* of modern authors, is now generally admitted. Parker and Jones indeed go a step further, and associate the typical *Asterigerina planorbis* of the "Vienna Basin" memoir and the *Rotalia rosacea* of the "Tableau Méthodique" as mere individual modifications of the same species. The difference between these two forms, as exemplified in the figures and model respectively, shows itself principally in the height of the spire, the former having a somewhat high conical test, the latter one of thin or more or less depressed contour.

The variability of the species with regard to the size and prominence of the umbilical lobes or valves is illustrated by the drawings furnished herewith, fig. 1 representing a specimen in which they are but slightly developed, leaving a central open cavity, whilst in fig. 4 they are very conspicuous, alternating with the primary segments and covering the umbilicus.

Discorbina rosacea is a common species. Within certain depths it is found in almost every sea, from the shores of Shetland and the Faröe Islands on the north to Magellans Strait on the south. Its home is on shallow bottoms, and it becomes rare at greater depths than 250 fathoms; but occasional specimens are met with as low as 1000 fathoms.

Its geological distribution commences with the Tertiary epoch. It occurs in the Eocene of Grignon, France (Parker and Jones); in the Miocene of various parts of the world (d'Orbigny, Parker and Jones, Seguenza); in the Pliocene of Italy (d'Orbigny, Seguenza); in the Crag of Norfolk and Suffolk (Jones, Parker, and Brady); and in the Post-pliocene of the British Islands (Shone, Robertson, Wright), and of the Island of Ischia (Vanden Broeck).

Discorbina vilardeboana, d'Orbigny, sp. (Pl. LXXXVI. figs. 9, 12; Pl. LXXXVIII. fig. 2).

Rosalina vilardeboana, d'Orbigny, 1839, Foram. Amér. Mérid., p. 44, pl. vi. figs. 13–15.
Discorbina vilardeboana, Parker and Jones, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 115.

Discorbina araucana, d'Orbigny, sp. (Pl. LXXXVI. figs. 10, 11).

Rosalina araucana, d'Orbigny, 1839, Foram. Amér. Mérid., p. 44, pl. vi. figs. 16–18.
Discorbina araucana, Parker and Jones, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 115.

These are two out of a number of almost indistinguishable varieties of *Discorbina* of the "*rosacea*" type, which are widely distributed in both hemispheres.

They occur in shallow water at almost every latitude, from the shores of Japan to Kerguelen Island and the coast of Patagonia.

Discorbina isabelleana, d'Orbigny, sp. (Pl. LXXXVIII. fig. 1, *a.b.c.*).

Rosalina isabelleana, d'Orbigny, 1839, Foram. Amér. Mérid., p. 43, pl. vi. figs. 10–12.
Discorbina isabelleana, Parker and Jones, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 115.

A minute thin-shelled variety also belonging to the "*rosacea*" group.

Dredged off Tahiti, 620 fathoms; found by d'Orbigny in sands from the Falkland Islands.

Discorbina eximia, Hantken (Pl. LXXXVIII. fig. 9, *a.b.*).

Discorbina eximia, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 76, pl. xv. fig. 8.
,, *elegans*, Id. Ibid. p. 76, pl. ix. fig. 3, *a.b.c.*

It appears to me scarcely possible to separate the *Discorbina eximia* and *Discorbina elegans* of von Hantken, and as the latter term is already in use for another modification of the genus,[1] the former may be adopted for the present variety.

Occurs at Station 185, off Raine Island, Torres Strait, 155 fathoms.

Von Hantken's specimens were from the later *Clavulina-szabói* formation of Hungary.

Discorbina concinna, n. sp. (Pl. XC. figs. 7, 8).

Test free; outline circular, superior face convex, inferior somewhat concave, peripheral edge angular; composed of somewhat more than two convolutions, of which the latest consists of from three to four segments. Earlier segments, in their superior aspect, short and radial later segments long and crescentiform; on the inferior side, the final segment occupying nearly half the entire surface, umbilical flaps distinct but not greatly developed. Walls very thin and conspicuously perforated; sutures marked by fine lines, neither depressed nor limbate externally. Diameter, $\frac{1}{100}$th inch (0·25 mm.).

It is possible that this little organism may be only the immature or arrested stage of some better-known species; but, though common in several localities, I have been unable to associate it with any of the larger modifications of the genus.

It inhabits tropical seas, occurring at two points off Tahiti, depth 420 fathoms and 620 fathoms; and at two off Kandavu, 255 fathoms and 610 fathoms respectively; also off Amboyna, 15 to 20 fathoms; off the Admiralty Islands, 16 to 25 fathoms; and off the Philippine Islands, 95 fathoms.

[1] *Discorbina elegans*, d'Orbigny, sp. (*Anomalina elegans*, *Ann. Sci. Nat.*, 1826, vol. vii. p. 282, No. 4;—Modèle, No. 42).

Discorbina orbicularis, Terquem, sp. (Pl. LXXXVIII. figs. 4–8).

Rosalina orbicularis, Terquem, 1876, Anim. sur la Plage de Dunkerque, p. 75, pl. ix. fig. 4, *a.b.*
Discorbis orbicularis, Berthelin, 1878, Foram. de Borgneuf et Pornichet, p. 39, No. 63.
Discorbina rosacea, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 200, pl. iii. figs. 54, 55.
„ *minutissima*, Seguenza, 1880, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 149 pl. xiv. fig. 1, 1, *a.b.*

The minute scale-like Foraminifer to which Terquem has given the name *Rosalina orbicularis* presents extremely variable characters. Typically the test is much depressed and its peripheral outline nearly circular; the superior face is convex or subconical, the inferior plane or concave, and the peripheral edge thin and sharp. In their superior aspect the segments are long, curved, and overlapping; those of the later convolutions extending to nearly half the circumference of the shell. The sutures are generally marked by fine lines, but occasionally are more or less limbate externally. On the inferior face only three, or at most four, segments are visible, the last occupying nearly half the entire area, the umbilical flaps being tolerably well marked. The walls are nearly always delicately thin and conspicuously perforated. The shell occasionally attains a diameter of $\frac{1}{30}$th inch (0·84 mm.), but more frequently does not much exceed half that size.

Terquem figures fossil specimens of the same form, but with the astral flaps more prominently developed, as *Asterigerina rhodiensis* (Mém. Soc. géol. France, sér. 3, vol. i., Mém. III. p. 31, pl. iii. figs. 1–4).

Discorbina orbicularis is best known as a coral-reef species, though by no means confined to such localities. It is plentiful in shallow water amongst the islands of the Pacific, and also amongst the West Indies. Rare specimens have been found as far north as the Atlantic shores of France (Terquem, Berthelin), and the east coast of Ireland (Balkwill); and as far south as the southern coast of Australia. Its ascertained range of depth is from the littoral zone to 435 fathoms.

As a fossil it occurs in the Miocene of Southern Italy (Seguenza), and in the Upper Pliocene sands of Rome (Terrigi).

Discorbina patelliformis, n. sp. (Pl. LXXXVIII. fig. 3, *a.b.c.*; Pl. LXXXIX. fig. 1, *a.b.c.*).

Test free; superior side conical, inferior flat, peripheral edge acute: in the adult state composed of fully three convolutions, of which the outermost has from five to seven segments; segments in their superior aspect long and narrow, the sutures and margin marked by broad lines of clear shell-substance, but not limbate externally. Superior surface smooth; inferior ornamented either with faint riblets radiating from the umbilicus

or with lines of closely-set granules, sometimes with larger tubercles near the centre. Diameter, about $\frac{1}{70}$th inch (0·36 mm.).

A variety resembling the more conical forms of *Discorbina rosacea*, but with thicker walls. The inferior face is flat and shows no Asterigerine flaps, but instead, a superficial ornament of exogenous costæ or tubercles.

Discorbina patelliformis is not uncommon amongst the islands of the Pacific, at depths of 6 to 150 fathoms. It has been observed also in shallow-water dredgings from the shores of Ceylon, Madagascar, the Mauritius, and Malta.

Discorbina tabernacularis, H. B. Brady (Pl. LXXXIX. figs. 5–7).

Discorbina tabernacularis, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 65.

Test free; contour that of a tall cone with somewhat convex sides and more or less concave base, often deeply sunken at the umbilicus. Segments long, oblique, arranged in about three convolutions; the septal lines of small or immature specimens limbate externally, those of larger shells concealed by the general thickening of the walls of the test. Inferior surface ornamented with radiating striæ or crenulations; superior with striæ or irregular costæ radiating from the apex. Diameter, $\frac{1}{100}$th inch (0·25 mm.) or less.

Discorbina tabernacularis is a minute coral-reef species. It sometimes occurs in pairs, that is to say, two shells firmly attached to each other by their bases (fig. 6), a condition more frequently observed in *Discorbina parisiensis*.

Specimens have been taken at nine localities amongst the islands of the South Pacific, depth from 2 fathoms to 255 fathoms, but chiefly in very shallow water; also off Honolulu, 40 fathoms; in harbour-mud from Port Louis, Mauritius; in shore-sand from Tamatavé, Madagascar; and off St. Vincent, Cape de Verde Islands, 11 fathoms.

Discorbina parisiensis, d'Orbigny, sp. (Pl. XC. figs. 5, 6, 9–12).

Rosalina parisiensis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 271, No. 1;—Modèle, No. 38.
Discorbina parisiensis, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. pl. ii. fig. 70.
" " (pars), Wright, 1877, Proc. Belfast Nat. Field Club, 1876–7, App., p. 105, pl. iv. fig. 1.
Discorbis parisiensis, Berthelin, 1878, Foram. de Bourgneuf et Pornichet, p. 40, No. 65.

The test of *Discorbina parisiensis* is plano-convex, sometimes obtusely pointed at the apex, the peripheral edge subangular. The segments are long, narrow, and much arched. In some specimens the final convolution alone is visible on the superior face (fig. 6, *a*), but more frequently the large primordial segment is also seen (fig. 9), and rarely portions of the earlier whorl or whorls. The sutures are marked by fine lines, and

are neither depressed nor limbate externally. The inferior side has a superficial ornament of radiating lines of minute tubercles.

This is one of several species of *Discorbina*, the shells of which are frequently found in pairs, two individuals adhering firmly to each other by their bases; a condition which has already been noticed in connection with *Textularia folium* (*ante*, p. 357). It is probable that the phenomenon is be accounted for in the same way in all cases, that it is brought about by the extension of a lobe of sarcode from the mouth of the parent test, the subsequent division of the nucleus, and the continued growth of the new individual without separation from the parent,—a very similar process to that minutely watched by Gruber in a species of *Euglypha*.[1]

Discorbina parisiensis was dredged in great abundance on the shores of Kerguelen Island, at depths of 20 to 50 fathoms, but the species was not taken at any other point of the Challenger voyage. A few small specimens have been obtained by Wright at similar or even less depths on the coast of Ireland, and by Berthelin on the Atlantic shores of France.

It was originally described by d'Orbigny as an Eocene fossil from the Paris Basin; it has been found also at several horizons of the Crag of Norfolk and Suffolk.

A closely allied species, *Discorbina wrightii*,[2] distinguished from the foregoing by its more regularly Rotaliform shell, its shorter and more numerous segments, and their arrangement in several convolutions, the whole of which are visible on the superior face, is represented in the Challenger gatherings by a single specimen dredged off Gomera, Canaries, 620 fathoms.

Discorbina pileolus, d'Orbigny, sp. (Pl. LXXXIX. figs. 2–4).

Valvulina pileolus, d'Orbigny, 1839, Foram. Amér. Mérid., p. 47, pl. i. figs. 15–17.
Discorbina pileolus, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 385.

A highly convex, dome-shaped, or subconical variety, with long, narrow, much curved segments, of which sometimes little more than the final convolution is visible externally; the inferior surface presenting a radiate ornament of riblets or granulose lines. Double specimens (figs. 2, 4), like those of *Discorbina parisiensis* and *Discorbina tabernacularis*, are not uncommon.

Discorbina pileolus occurs at three Challenger Stations:—Port Jackson, 2 to 10 fathoms; off Tongatabu, Friendly Islands, 18 fathoms; and Simon's Bay, Cape of Good Hope, 15 to 20 fathoms; also at the following localities,—Port Stephens, New South Wales; Curtis Strait, Queensland; off Levuka, Fiji, 12 fathoms; Port Elizabeth, Algoa Bay; and, as stated by d'Orbigny, near Arica, on the coast of Peru.

It has been found as a fossil in the Eocene deposits of Grignon, France (Parker and Jones), and in the Miocene of the Island of Malta (Brady).

[1] *Zeitschr. f. Wiss. Zool.*, vol. xxxv. pp. 431–439, 1881.
[2] Brady, *Denkschr. d. k. Akad. Wiss. Wien*, vol. xliii. p. 104, pl. ii. fig. 6.

Discorbina opercularis, d'Orbigny, sp. (Pl. LXXXIX. figs. 8, 9).

Rosalina opercularis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 271, No. 7.
„ „ Id. 1839, Foram. Cuba, p. 101, pl. iii. figs. 24, 25 ; pl. iv. fig. 1.
Discorbina opercularis, Parker and Jones, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 114.

A thin, depressed, convex or subconical variety, the superior face exhibiting two to three convolutions with very numerous, narrow, arcuate segments; the inferior face ornamented with faint riblets or tubercles.

This form has been observed at four points on the coast of Australia, namely :—off Raine Island, Torres Strait, 155 fathoms; off East Moncœur Island, Bass Strait, 38 fathoms; Port Jackson, 2 to 10 fathoms; and Curtis Strait, Queensland; and also, according to d'Orbigny, in the shore-sands of Cuba and Martinique, West Indies.

Discorbina pulvinata, n. sp. (Pl. LXXXVIII. fig. 10, *a.b.*).

Test broadly ovate or subglobular, somewhat depressed; composed of a few more or less inflated segments, about three in the final convolution; superior face rugose externally; inferior deeply excavated at the umbilicus and ornamented with radiating granulose lines. Diameter, $\frac{1}{90}$th inch (0·28 mm.).

The foregoing provisional description is intended to characterise an obscure obese variety of *Discorbina* which does not appear to be otherwise provided for. Its nearest ally is perhaps the *Discorbina platyomphala* of Reuss (Sitzungsb. d. k. Ak. Wiss. Wien, 1867, vol. lv. p. 102, pl. iv. fig. 13).

The specimens were found in anchor-mud from Nares Harbour, Admiralty Islands, 17 fathoms; and off Booby Island, south of Papua, 6 to 8 fathoms.

Discorbina bertheloti, d'Orbigny, sp. (Pl. LXXXIX. figs. 10–12).

Rosalina bertheloti, d'Orbigny, 1839, Foram. Canaries, p. 135, pl. i. figs. 28–30.
Discorbina bertheloti, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 469, pl. xlviii. fig. 10, *a.b.*
„ *turbo*, var. *parisiensis*, subvar. *berthelotiana*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 387, pl. xvi. figs. 26, 27.

Discorbina bertheloti has a thin outspread test, of which the more distinctly spiral face is flat or nearly so; the reverse side convex. It is isomorphous with the more depressed varieties of *Truncatulina lobatula*, from which it may generally be known by its somewhat large final segment and its thinner and more finely perforated walls.

Though nowhere very common, *Discorbina bertheloti* is widely distributed. A list of from twenty to thirty localities embraces points in the Arctic Ocean, the North and South Atlantic, the North and South Pacific, and the Mediterranean,—the northernmost being on the shores of Novaya Zemlya, the most southerly at the south-eastern corner of Australia. The home of the species is at depths of less than 500 fathoms, but occasional

specimens have been obtained as low as 1070 fathoms in the North Atlantic, and 2160 fathoms in the South Pacific.

Discorbina bertheloti, var. *baconica*, Hantken, var. (Pl. XC. fig. 1, *a.b.c.*).

Discorbina baconica, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 76, pl. x. fig. 3, *a.b.*

This is an unimportant variety, the test of which is somewhat more stoutly built than that of the typical *Discorbina bertheloti*, and the margins of the segments on the superior side, as well as the periphery of the inferior, are limbate or bordered; but it is not distinguishable from the commoner form by any characters of greater significance.

Specimens corresponding to the original figures have been obtained from two localities in the North Atlantic, depth 600 fathoms and 1180 fathoms respectively.

Those described by von Hantken were fossils from the upper *Clavulina-szabói* formation of Hungary.

Discorbina rarescens, n. sp. (Pl. XC. figs. 2, 3; and 4 ?).

Test free or adherent, plano-convex; peripheral edge extended so as to form a well-defined keel, often of considerable width; the five segments of the outermost whorl alone visible on the convex face, the last chamber being relatively large, and the sutures even and marked only by fine lines; spiral face somewhat depressed at the umbilicus, the valvular lobes of later segments tolerably distinct. Diameter, $\frac{1}{40}$th inch (0·63 mm.).

Discorbina rarescens is a carinate variety, bearing the same sort of relation to *Discorbina bertheloti* that *Truncatulina tenuimargo* bears to *Truncatulina lobatula*.

It has been met with off Raine Island, Torres Strait, at a depth of 155 fathoms; and off the Philippines, 95 fathoms.

Discorbina vesicularis, Lamarck, sp. (Pl. LXXXVII. fig. 2, *a.b.c.*).

Discorbites vesicularis, Lamarck, 1804, Ann. du Muséum, vol. v. p. 183; vol. viii., pl. lxii. fig. 7.
„ „ Defrance, 1824, Dict. Sci. Nat., vol. xxxii. p. 186;—Atlas Conch., pl. xiv. fig. 2.
„ „ Blainville, 1825, Malacologie, pl. vi. fig. 2.
Rotalia turbo, var. *vesicularis*, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 293, No. 6.
Discorbina vesicularis, Carpenter, 1862, Introd. Foram., p. 204, pl. xiii. figs. 2, 3.
„ *turbo*, var. *vesicularis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 385.

Some interest attaches to this species from the fact that the segments are separated externally by deep fissures; as well as from the remarkable development of the secondary

lobes or flaps, which give to the inferior face of the test its "vesicular" aspect. Under favourable conditions the shell attains a diameter of $\frac{1}{18}$th to $\frac{1}{15}$th inch (1·4 to 1·7 mm.).

The *Rotalia* (*Discorbis*) *gervillii* of d'Orbigny (Modèle, No. 72) appears to be a compressed, thin-edged variety of the same species.

Discorbina vesicularis has been taken at four Stations near the coast of New Guinea, namely:—Humboldt Bay, 37 fathoms; Flinders Passage, 7 fathoms; off Booby Island, 6 to 8 fathoms; and off Raine Island, 155 fathoms; and at one point off the Fiji Islands, 210 fathoms. It is common in the shore-sands of Melbourne, Australia (Parker and Jones), and of Tamatavé, Madagascar.

It occurs as a fossil in the Eocene of the vicinity of Paris (Lamarck, d'Orbigny), and in the Post-pliocene beds of Norway (Sars).

Discorbina rugosa, d'Orbigny, sp. (Pl. LXXXVII. fig. 3, *a.b.c.*; Pl. XCI. fig. 4, *a.b.c.*).

Rosalina rugosa, d'Orbigny, 1839, Foram. Amér. Mérid., p. 42, pl. ii. figs. 12–14.

A more or less explanate modification of *Discorbina*, resembling *Anomalina ammonoides* in general contour. The test is compressed and exhibits some approach to bilateral symmetry, and the peripheral edge is round and lobulated. The umbilical cavity of the inferior side is partially covered in by the valvular flaps protecting the successive apertures. The drawings (Pl. LXXXVII. fig. 3) are taken from a typical example. A comparatively minute, compactly built variety, with more numerous and less ventricose segments, is represented in Pl. XCI. fig. 4.

Discorbina rugosa has been obtained from two Stations on the southern shores of Papua, namely,—off Raine Island, 155 fathoms; and off Ki Islands, 580 fathoms. The locality quoted by d'Orbigny is the Bay of St. Blas, Patagonia.

Discorbina polystomelloides, Parker and Jones (Pl. XCI. fig. 1, *a.b.c.*).

Discorbina polystomelloides, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 421, pl. xix. fig. 8, *a.b.c.*

This strongly-marked species is stated by Parker and Jones to be "a granulose form of *Discorbina rimosa*, but larger, more symmetrical, and extremely rough; and the chinks between the chambers partly bridged over, so as to form a rough canal system, as in some of the *Polystomellæ*." The diameter of some of the Challenger specimens is fully $\frac{1}{15}$th inch (1·68 mm.).

Discorbina polystomelloides occurs at three Stations amongst the islands south of New Guinea, namely:—off Booby Island, 6 to 8 fathoms; off Wednesday Island, 8 fathoms; and Flinders Passage, 7 fathoms. The locality given with the original description is the Australian coral-reefs.

Discorbina biconcava, Parker and Jones (Pl. XCI. figs. 2, 3).

Discorbina biconcava, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 422, pl. xix. fig. 10, *a.b.c.*
„ „ Siddall, 1878, Proc. Chester Soc. Nat. Sci., pt. 2, p. 50.

This species is described by Parker and Jones (*loc. cit.*) as "a very small isomorph of *Planulina ariminensis;* a hyaline, thick, limbate, square-edged, biconcave *Discorbina*, most concave on the umbilical face, and with feeble astral flaps."

The small size is an occasional rather than an invariable feature, for under favourable circumstances the test attains nearly the same dimensions as that of *Anomalina* (*Planulina*) *ariminensis*. The sutural limbation of small shells (fig. 3) is often confined to the inferior face.

Discorbina biconcava has been met with at three Challenger Stations, all of them on the coast of Australia:—off East Moncœur Island, Bass Strait, 38 fathoms; Port Jackson, 2 to 10 fathoms; and off Raine Island, Torres Strait, 155 fathoms. Prof. Parker's specimens were found in shore-sand from Melbourne, and in my own cabinet there are good examples from Storm Bay, Tasmania. Mr. J. D. Siddall has minute but well characterised shells from the estuary of the Dee; and but for this fact, the species might be supposed to belong exclusively to Australia and the neighbouring islands.

Discorbina saulcii, d'Orbigny, sp. (Pl. XCI. fig. 6, *a.b.c.*).

Rosalina saulcii, d'Orbigny, 1839, Foram. Amér. Mérid., p. 42, pl. ii. figs. 9–11.
Discorbina saulcii, Parker and Jones, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 156.

The general contour of the test forms perhaps the most distinctive specific feature of *Discorbina saulcii*, the superior or spiral face being flat, the inferior or apertural side convex, and the peripheral edge subangular or rounded. The length and degree of curvature of the segments, as seen on the superior side, are subject to considerable variation; and in most of the specimens which have come under my notice they are longer, narrower, and more bent than depicted by d'Orbigny. The degree of development of the umbilical lobes is also very different in different shells, the central vestibule being sometimes completely closed, as indicated by the original drawings, but more frequently only partially occupied, leaving a deep umbilical cavity (fig. 6, *b*). Variability in this

latter particular is by no means confined to the present species, but may be noticed amongst allied forms.

Discorbina saulcii occurs in two soundings off Tahiti, at depths of 420 and 620 fathoms respectively. Fine well-characterised specimens were abundant in sand dredged by the late Mr. M'Andrew in the Gulf of Scala Nova, Levant, depth 100 fathoms. The habitat named by d'Orbigny is the shore-sand of Arica, Peru.

Discorbina allomorphinoides, Reuss, sp. (Pl. XCI. figs. 5, 8).

Valvulina allomorphinoides, Reuss, 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xl. p. 223, pl. xi. fig. 6.

I think I am right in referring certain recent specimens, exemplified by the two figures 5 and 8, to Reuss's Cretaceous species; and also in placing them amongst the *Discorbinæ*, notwithstanding the fine texture and minute perforation of the shell-wall, which suggest rather an affinity to *Pulvinulina*. Their connection with more typically constructed *Discorbinæ* is more easily traced in some specimens than others, and even when least apparent may generally be recognised by comparison with forms bearing intermediate characters.

The specimens alluded to were collected at three localities, namely:—off the Philippine Islands, 95 fathoms; off Raine Island, 155 fathoms; and at Port Jackson, 2 to 10 fathoms.

The original *Valvulina allomorphinoides* of Reuss was from the Cretaceous formations of Westphalia.

Discorbina ventricosa, n. sp. (Pl. XCI. fig. 7, *a.b.c.*).

Test free, oblong, rounded, more or less depressed; composed of less than two complete convolutions, the outer whorl consisting of six or seven segments; the successive segments increasing rapidly in length; septal faces ventricose, especially that of the final chamber; sutures excavated. Superior face hispid externally, inferior smooth; umbilicus deeply sunk, valvular flaps but little developed. Diameter, about $\frac{1}{50}$th inch (0·5 mm.).

The affinity of this little Foraminifer is somewhat obscure. If correctly assigned to the present genus, it may be ranked as a Discorbine isomorph of *Pulvinulina hauerii* or *oblonga*.

The best specimens occur in material dredged off Bermuda, 435 fathoms; but similar forms have been observed off Gomera, Canaries, 620 fathoms; off the Azores, 450 fathoms; and off Raine Island, 155 fathoms.

Planorbulina, d'Orbigny (*emend.* Carpenter, Parker, and Jones).

Planorbulina, Truncatulina, Anomalina, Siphonina, et *Planulina*, auctorum.

In its full generic significance the term *Planorbulina* embraces too large an array of closely related forms to be conveniently handled as a single group. To obviate the difficulties attendant on the collective treatment of so extensive a series, Dr. Carpenter and his colleagues recognise the d'Orbignian genera *Planorbulina*, *Truncatulina*, and *Anomalina* as representing three subordinate types of sub-generic or quasi-generic value,[1] and a similar course has been pursued by von Reuss.[2]

Under this arrangement *Planorbulina* comprises the outspread varieties, the earlier segments of which (in typical specimens) are arranged on a plano-spiral plan, whilst those subsequently formed are disposed in more or less regular annuli; and the individual chambers have marginal orifices, of which those of the outermost whorl constitute the general aperture of the test.

To *Truncatulina* are allotted the more distinctly Rotaliform species, spiral throughout, either plano-convex in contour, the whole of the segments being visible on one side, and only those of the final convolution on the other, or else biconvex, the convolutions embracing each other to a greater or less degree, though unequally, on both faces of the test.

Anomalina, on the other hand, includes those forms in which the spire not only approaches something like bilateral symmetry, but is, at the same time, more or less evolute, the contour of the shell being either biconcave and coronate or nearly complanate.

The genera *Siphonina* of Reuss and *Planulina* of d'Orbigny appear needless additions to the nomenclature. Hitherto they have each been represented by a single specific form, which may be assigned in the one case to *Truncatulina* and in the other to *Anomalina*.

Amongst *Rotalinæ* the genus *Planorbulina* is characterised typically by the coarsely perforated test, and by the aperture which has often a thickened lip or rim, developed in some cases to such an extent as to become a short, oval or rounded neck. The exterior of the shell is most frequently smooth, but it is subject to superficial decoration in the form of limbation of the sutures, exogenous tubercles, or a fringed condition of the margin.

The genus *Planorbulina*, in one or other of its modifications, is common to the seas of all latitudes, and its bathymetrical range extends from the littoral zone down to 3000 fathoms or perhaps more. Its distribution, from the geological standpoint, dates back as far as the Carboniferous epoch; it is rare in the Lias, but becomes comparatively abundant during the Cretaceous period, and furnishes a fair proportion of the Rotaline species of every division of the Tertiary system.

[1] Introd. Foram., p. 206.

[2] Das Elbthalgebirge in Sachsen, 2ter Theil, p. 113.

Planorbulina (*s. str.*), d'Orbigny.

Planorbulina, d'Orbigny, [1826], Bronn, Münster, Roemer, Hagenow, Reuss, Costa, Williamson, Parker and Jones, Carpenter, Karrer, Brady, M. Sars, Fischer, Schulze, Terquem, &c.

The test of *Planorbulina*, using the term in its limited sense, has the form of a complanate or somewhat plano-convex disk, which under ordinary circumstances grows attached to algæ, fragments of shell, or other foreign bodies. It consists typically of a single layer of chambers, the whole of which are seen on both faces of the test. In the early stage the segments are arranged in a depressed spire, each segment having an orifice at its inner peripheral margin; subsequently the mode of growth becomes more or less distinctly cyclical, the segments of the successive annuli alternating with each other. In this later stage the individual segments have two small lipped orifices, one at each extremity, close to the line of union with the previous whorl; and the adjacent orifices of each two chambers open into the intermediate segment of the next annulus; whilst those of the outermost row appear externally and form collectively the general aperture of the test. Morphologically the attached side of the shell is its superior face.

A departure from the typical plan of growth is exhibited by certain acervuline varieties, in which a number of small chambers, crowded together without order or regularity, cover the free or inferior face of the shell.

Planorbulina most affects the shallow-water margins of the seas of temperate and tropical latitudes. At depths greater than 100 fathoms the genus becomes rare, but it has been taken as low as 600 fathoms, and in one locality down to 1125 fathoms. Its earliest appearance as a fossil is at about the middle of the Tertiary epoch, and it is not uncommon in later Tertiary formations.

Planorbulina mediterranensis, d'Orbigny (Pl. XCII. figs. 1–3).

"Corpuscula *plano-papillosa*," Soldani, 1795, Testaceographia, vol. i. pt. 3, p. 238, pl. clxi. figs. *E.F.G.*—pl. clxii. fig. *H.*

Planorbulina mediterranensis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 280, pl. xiv. figs. 4–6;—Modèle, No. 79.

„ *vulgaris*, Id. 1839, Foram. Cuba, p. 85, pl. vi. figs. 11–15.

„ „ Id. 1839, Foram. Canaries, p. 134, pl. ii. fig. 30.

„ „ Williamson, 1858, Rec. For. Gt. Br., p. 57, pl. v. figs. 119, 120.

„ *farcta*, var. *mediterranensis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 383, pl. xvi. fig. 21.

„ *mediterranensis*, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 178, pl. xii. fig. 133.

The common typical species of *Planorbulina* has a thin, outspread shell, the superior or attached surface of which is flat, or nearly so, and the inferior uneven and lobulated,

the peripheral outline being either irregular and subangular, as in figs. 1, 2, or almost circular, as in fig. 3. The segments are inflated and slightly embracing on the free side of the test, but their form and mode of combination are generally more distinctly seen on the superior or attached face. Average specimens have a diameter of about $\frac{1}{25}$th inch (1 mm.).

Under the name *Planorbulina retinaculata*, Parker and Jones have described a curious modification of the present species, "which, besides being scabrous with granulation [like *Planorbulina larvata*]. develops a large number of peripheral, subsidiary, tubular apertures, connecting together, and still keeping apart, the sarcode-chambers, and forming a kind of irregular network over the surface of the shells on which it grows" (Phil. Trans. vol. clv. p. 380, pl. xix. fig. 2).

Planorbulina mediterranensis is found in almost every sea within the temperate and tropical zones. It is commonest at depths of less than 50 fathoms; but it occurs sparingly in the North Atlantic at 430, 600, and 635 fathoms, and a single specimen has been obtained from a sounding taken north of the Canaries, at 1125 fathoms. In the South Atlantic it extends to a depth of 350 fathoms, and in the South Pacific as far as 255 fathoms.

As a fossil the species has been observed in the Miocene of the Vienna Basin (d'Orbigny), in the later Tertiaries of Italy and Sicily (Jones and Parker, Seguenza); in the Crag of the east of England (Jones, Parker, and Brady), in the Post-tertiary formations of Norway (Sars, Crosskey, and Robertson), of Scotland (Robertson), of Ireland (Wright), and of the Island of Ischia (Vanden Broeck); and in the Fen-clays of Lincolnshire and Cambridgeshire (Parker and Jones).

Planorbulina acervalis, n. sp. (Pl. XCII. fig. 4).

Test normally adherent, discoidal; superior (attached) face flat, inferior more or less convex; margin lobulated, with interspaces between the segments of the final whorl. General structure resembling that of *Planorbulina mediterranensis*, with the addition of a mass of minute acervuline segments covering to a greater or less thickness the free surface of the test. Diameter, $\frac{1}{25}$th inch (1 mm. or more).

The acervuline varieties of *Planorbulina* are distinguished from corresponding modifications of *Tinoporus* (*Gypsina*) by the retention of the normal Planorbuline arrangement of the segments on the attached face of the shell, and more especially by the peripheral apertures.

Such forms are not uncommon amongst the islands of the Pacific, as well as in the Indian Ocean, and in the Red Sea. They frequent shallow water, and are most plentiful on bottoms of less than 20 or 30 fathoms, but are sometimes found at much greater depths.

Planorbulina larvata, Parker and Jones (Pl. XCII. figs. 5, 6).

Planorbulina vulgaris, var. *larvata*, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 294.
„ *larvata*, Id., 1865, Phil. Trans., vol. clv. p. 379, pl. xix. fig. 3, *a.b.*

This is a symmetrically-formed parasitic variety, characterised by its relatively thick walls and the granular or tuberculate condition of the exterior, especially near the centre of the disk. The segmentation is often indistinct externally, but the marginal apertures are generally well defined and conspicuous.

Planorbulina larvata is an exclusively tropical species. It occurs at seven Stations amongst the islands of the South Pacific, at depths varying from 15 to 210 fathoms, chiefly in coral-sands. It has also been obtained from the Honolulu Reefs, 40 fathoms, and from the Chinese Sea.

Truncatulina, d'Orbigny.

Nautilus, pars, Walker and Boys [1784], Fichtel and Moll, Maton and Rackett, Turton, Pennant, Dillwyn.
Serpula, pars, Montagu [1803].
Rotalia, pars, Lamarck [1804], d'Orbigny, Roemer, Reuss, Karrer, Stache, Gümbel.
Polyxenus, Montfort [1808].
Cibicides, Montfort [1808], Blainville.
Cristellaria, pars, Lamarck [1822].
Truncatulina, d'Orbigny [1826], Bronn, Münster, Roemer, Reuss, Costa, Egger, Parker and Jones, Williamson, Karrer, Seguenza, Brady, Dawson, M. Sars, Hantken, Winther, Wright, Terquem, &c.
Lobatula, Fleming [1828], Thorpe.
Rosalina, pars, d'Orbigny [1839], Alth, Reuss, Stache, Gümbel.
Rotalina, pars, d'Orbigny [1839], Czjzek, Reuss, Bailey, Bornemann, Egger, Karrer, Seguenza, Martonfi.
Discorbis, Macgillivray [1843].
Anomalina, pars, d'Orbigny [1846], Schwager.
Siphonina, Reuss [1849], Costa, Karrer, Terrigi, Seguenza.
Planorbulina, pars, Parker and Jones [1860], Carpenter, Brady, Siddall.

In the arrangement which has been followed, the Truncatuline group of *Planorbulinæ* is limited to those species in which the spire is either Rotaliform, that is to say, completely involute on the inferior aspect and evolute on the superior, or else more or less involute on both sides. Such varieties find their typical representative in the common *Truncatulina lobatula*,—a plano-convex shell of parasitic habit, growing adherent by its flat superior face. By imperceptible gradations the plano-convex forms pass into the biconvex, some of which, like *Truncatulina haidingerii*, retain the Rotaliform disposition of the segments, whilst others, such as *Truncatulina rostrata*, become almost Nummuline in the embracing contour and bilateral symmetry of the convolutions.

Of the biconvex varieties there is a small but very interesting series, separated by Reuss from the rest of the genus under the name *Siphonina*, characterised by an exaggerated development of the lipped orifice, and by a tendency to marginal decoration. It is difficult, perhaps impossible, to distinguish these forms as a generic group, by any sufficiently precise or constant characters, from the more normally constructed shells, although they appear to present well-marked minor features. Their typical structure is best exemplified in *Truncatulina reticulata*, which, nevertheless, is an exceedingly variable organism; and to a less degree in *Truncatulina soluta* and *Truncatulina echinata*.

Occasionally the stouter varieties of *Truncatulina* have limbate sutures, but with this exception the shell is rarely endowed with external ornament of any kind; sometimes, however, the surface is beset with raised tubercles, irregularly disposed, and one or two species already referred to display a fringe-like marginal extension of the chamber-walls.

Truncatulina refulgens, Montfort, sp. (Pl. XCII. figs. 7–9).

"Hammonia *Balanus* seu *Balanoidea*," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 58, pl. xlvi. figs. *nn*, *oo*.
Cibicides refulgens, Montfort, 1808, Conchyl. Systém., vol. i. p. 122, 31e Genre.
Truncatulina refulgens, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 279, pl. xiii. figs. 8–11;—Modèle, No. 77.
" " Parker and Jones, 1865, Phil. Trans., vol. clv. p. 382, pl. xvi. fig. 19.
" " Brady, 1865, Nat. Hist. Trans. Northd. and Durham, vol. i. p. 105, pl. xii. fig. 9, *a.–c.*

This is a stoutly-built, thick-shelled variety, the test of which, in well-developed examples, is bell-shaped or subconical, and the sutures complanate or but little depressed externally. It is isomorphous with *Pulvinulina micheliniana*, with which species it has sometimes been confounded.

Truncatulina refulgens is moderately common over a considerable area of the North Atlantic, between lat. 47° and lat. 62° N. On this ground it has been collected at twelve Stations, the depths of which range from 45 fathoms to 2400 fathoms. It occurs also in the Mediterranean and the Adriatic. Avoiding the tropics, it reappears in the temperate zone of the southern hemisphere,—off the Cape of Good Hope, 150 fathoms; on the east coast of Australia; and at several points on the western shores of Patagonia,—at depths of 50 to 250 fathoms.

Less is known of its distribution as a fossil. It has, however, been obtained from the Pliocene beds of Southern Italy (Seguenza); from the Red Crag of Essex (Jones, Parker, and Brady); from the Glacial-clays of Norway (Crosskey and Robertson); and from the Post-glacial deposits of the north-east of Ireland (Wright).

Truncatulina lobatula, Walker and Jacob, sp. (Pl. XCII. fig. 10; Pl. XCIII. figs. 1, 4, 5; Pl. CXV. figs. 4, 5).

"Nautilus spiralis lobatus, &c.," Walker and Boys, 1784, Test. Min., p. 20, pl. iii. fig. 71.
Hammoniæ tuberculatæ, &c.," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 58, pl. xlv. figs. *ii, kk, ll, mm.*
Nautilus lobatulus, Walker and Jacob, 1798, Adams's Essays, Kanmacher's Ed., p. 642, pl. xiv. fig. 36.
Serpula lobatula, Montagu, 1803, Test. Brit., p. 515, Suppl., p. 160.
Truncatulina tuberculata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 279, No. 1;—Modèle, No. 37.
„ *lobatula*, Id. 1839, Foram. Canaries, p. 134, pl. ii. figs. 22–24.
Discorbis lobatulus, Macgillivray, 1843, Moll. Anim. Aberd., p. 34.
Lobatula vulgaris, Thorpe, 1844, Brit. Mar. Conch., p. 235.
Truncatulina lobatula, d'Orbigny, 1846, For. Foss. Vien., p. 168, pl. ix. figs. 18–23.
„ *boueana*, Id. Ibid. p. 169, pl. ix. figs. 24–26.
Anomalina variolaria, Id. Ibid. p. 170, pl. ix. figs. 27–29.
Truncatulina communis, Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 242, pl. v. fig. 56.
„ *lobatula*, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 293, pl. x. figs. 17–21.
„ „ Williamson, 1858, Rec. For. Gt. Br., p. 59, pl. v. figs. 121–123.
„ *varians*, Reuss, 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlii. p. 359, pl. ii. fig. 12, *a.b.c.*
„ *dekayi*, Id. 1861, Ibid. vol. xliv. p. 338, pl. vii. fig. 6, *a.b.c.*
Planorbulina farcta, var. (*Truncatulina*) *lobatula*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 381, pl. xiv. figs. 3–6; pl. xvi. figs. 18–20.
Truncatulina lobatula, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, pl. ii. figs. 4–10; pl. iv. fig. 18.

It is impossible to define by any precise characters the morphological range of the present species. Its variations are infinite. The more convex forms lose themselves in *Truncatulina refulgens*, the more complanate in *Truncatulina wuellerstorfi*; the more regular and compactly built specimens constitute the *Truncatulina boueana* of d'Orbigny, the less regular the *Truncatulina variabilis* of the same author, and the links connecting it with the typical *Planorbulinæ* are furnished by the *Nautilus farctus* of Fichtel and Moll. The foregoing synonymy is limited to forms bearing the common every-day characters of the species, and a much larger list might be compiled without any violence to natural relationship.

Truncatulina lobatula is the commonest and perhaps the best known of all Rotaline Foraminifera; it nevertheless presents one interesting peculiarity that seems to have escaped notice heretofore, namely, the tendency displayed by adherent specimens to form for themselves a covering of loosely agglutinated sand. The drawings (Pl. CXV. figs. 4 and 5) represent two examples of this habit of growth: in fig. 4 the sandy nidus remains in its natural condition, intact; in fig. 5 a portion of the covering has been removed to

show the calcareous shell within. When the contour of the sandy envelope is regular and convex, as in the former case, the specimens may easily be mistaken at first sight for *Webbina hemisphærica*, though always distinguishable by the different mode of aggregation of the sand-grains, which in the present species are retained in their position chiefly, if not entirely, by the sarcode of the living animal, whilst in *Webbina* they are embedded in inorganic cement and form a compact wall. A similar tendency to form a protective rampart of sand is noticeable in certain other species of adherent Foraminifera, notably in some arenaceous or subarenaceous types, such as *Valvulina*, but seldom to the extent of providing a complete covering.

Truncatulina lobatula is common at every latitude, from the most northerly points of the Arctic Ocean yet explored to the Antarctic Ice-barrier. Bathymetrically speaking, it is most abundant in the littoral, laminarian, and coralline zones, but it is by no means confined to shallow bottoms, and is still conspicuous at depths of nearly 3000 fathoms.

Its geological distribution is also very extensive. Specimens of the compact variety have been met with in rocks of Carboniferous age; and shells indistinguishable from those living at the present day on our own shores are found in the later Mesozoic formations, and in almost every marine deposit of Tertiary and Post-tertiary times.

Truncatulina variabilis, d'Orbigny (Pl. XCIII. figs. 6, 7).

"Testæ hammoniformes, *plano-cochleatæ*, *tuberosæ articulatæ*, &c.," Soldani, 1789, Testaceographia, vol. i. pt. 1, pp. 77–80, pls. lxx.–xcii.
Truncatulina variabilis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 279, No. 8.
„ *innormalis*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 368, pl. xxi. fig. 11.
Planorbulina truncata, Egger, 1857, Neues Jahrb. für Min., &c., p. 280, pl. x. figs. 15–17.
Truncatulina tuberosa, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 177, pl. xii. fig. 138.
„ *variabilis*, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i., Mém. III., p. 20, pl. i. figs. 18–25.

The wild-growing adherent *Truncatulinæ*, to which Soldani devotes upwards of twenty plates of the "Testaceographia," without exhausting their multiform aspects, are grouped by d'Orbigny under a single specific name, *Truncatulina variabilis*.

Such varieties occur in greater or less numbers wherever the more normally constructed shells are at all abundant, but they are commonest at the shallow margins of subtropical and temperate seas. They are not, however, entirely confined to shallow water, for occasional specimens have been met with at depths of 500 or 600 fathoms, and in one instance at upwards of 2000 fathoms.

As a fossil *Truncatulina variabilis* has probably a similar range to *Truncatulina lobatula*, though there appears to be no mention of its occurrence in any formation earlier than the Eocene of the Paris Basin (Terquem). It has been obtained from the

Miocene of Lower Bavaria (Egger), and from the later Tertiaries of Southern Italy (Costa), and of the Island of Rhodes (Terquem).

Truncatulina tenuimargo, n. sp. (Pl. XCIII. figs. 2, 3).

General structure of the test similar to that of *Truncatulina lobatula*, from which it differs mainly in the extension of the peripheral borders of the segments, so as to form a well-defined, continuous, marginal wing or keel. Diameter, $\frac{1}{50}$th inch (0·5 mm.).

Truncatulina tenuimargo is a small carinate modification, seldom attaining the average dimensions of the typical form. As in *Truncatulina lobatula*, the disposition of the convolutions varies considerably in different specimens. The variety is distinguished from *Truncatulina culter*, P. and J., which also has a carinate shell, by its comparatively small number of segments and the simpler construction of the test, and frequently also by having a depressed or excavated umbilicus.

Out of the eight localities at which *Truncatulina tenuimargo* has been observed, four are referrible to the east coast of Australia and the neighbouring shores of New Zealand, depth from 38 to 1100 fathoms. The remainder are,—Torres Strait, 155 fathoms; off the Ki Islands, 129 fathoms; off the Fiji Islands, 255 fathoms; and one point in the South Atlantic, north of the Falkland Islands, 1035 fathoms.

Truncatulina wuellerstorfi, Schwager, sp. (Pl. XCIII. figs. 8, 9).

> *Anomalina wüllerstorfi*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 258, pl. vii. figs. 105, 107.

The thin, outspread, intermediate forms connecting *Truncatulina lobatula* with *Anomalina ariminensis* are well typified by the *Anomalina wuellerstorfi* of Schwager's memoir. The superior face of such shells is slightly convex, the inferior nearly flat, and the peripheral edge acute; the chambers are narrow and much curved, often almost crescentiform in outline. Of the drawings, fig. 9 represents the more typical specimen.

Truncatulina wuellerstorfi is a common constituent of the deep-water ooze of all the great oceans. The catalogue of localities at which it has been noticed includes fifteen Stations in the North Atlantic, depth from 350 to 2435 fathoms; seven in the South Atlantic, 675 to 2350 fathoms; one in the Southern Ocean, 1570 fathoms; thirteen in the South Pacific, 210 to 1940 fathoms; and three in the North Pacific, 345 to 2050 fathoms.

The fossil specimens from which the species was originally described were found by Dr. Schwager in the Pliocene deposits of Kar Nicobar.

Truncatulina haidingerii, d'Orbigny, sp. (Pl. XCV. fig. 7, *a–c*).

Rotalina haidingerii, d'Orbigny, 1846, For. Foss. Vien., p. 154, pl. vii. figs. 7–9.
„ *ehrenbergii*, Bailey, 1851, Smithsonian Contrib., vol. ii., art. 3, p. 10, figs. 11–13.
Rotalia brueckneri, Reuss, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 273, pl. ix. fig. 7.
„ *propinqua*, Id. 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 241, pl. iv. fig. 53, *a.b.c.*
Planorbulina haidingerii, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 469, pl. xlviii. fig. 11.
„ *farcta*, var. *haidingerii*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 382, pl. xvi. fig. 22, *a.b.*
Truncatulina haidingeri, Reuss, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 28.

A comparatively large variety, with stoutly built Rotaliform test, both faces of which are highly convex.

The Challenger collections have supplied no very good specimens of *Truncatulina haidingerii*. A few examples of the species, for the most part indifferently characterised, were collected at one Station in the North Atlantic, at two in the South Atlantic, at two in the Southern Ocean, and at seven in the South Pacific. Parker and Jones record its occurrence in the North Atlantic, 1776 fathoms; in the South Atlantic, 260 fathoms; in the Indian Ocean, 1120 fathoms; in the Mediterranean, 90 to 360 fathoms; and in the Red Sea, 320 to 678 fathoms.

It appears to be more common as a Tertiary species, having been observed in the Eocene formations of Paris (Terquem), and of the London Basin (Jones and Parker), in the middle Tertiaries of various parts of Central Europe (d'Orbigny, Reuss, &c.), and in the later Tertiaries of Italy, Sicily, and Spain (Jones and Parker, Seguenza).

Truncatulina akneriana, d'Orbigny, sp. (Pl. XCIV. fig. 8, *a.b.c.*).

Rotalina akneriana, d'Orbigny, 1846, For. Foss. Vien., p. 156, pl. viii. figs. 13-15.
Truncatulina akneriana, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 160, No. 6.

The superior face of the test of *Truncatulina akneriana* is flat, the inferior convex at the margin but depressed towards the umbilicus; and the convolutions are not completely involute on the inferior side, as in *Truncatulina lobatula*, but leave a portion of the earlier whorls visible at the centre.

This is one of those intermediate varieties of which it is almost impossible to lay down either the geographical distribution or the geological range, as distinct from that of the allied forms. It is commonly found associated either with *Truncatulina lobatula* or *Truncatulina ungeriana*, often with both.

Truncatulina ungeriana, d'Orbigny, sp. (Pl. XCIV. fig. 9, *a.b.c.*).

Rotalina ungeriana, d'Orbigny, 1846, For. Foss. Vien., p. 157, pl. viii. figs. 16–18.
,, *granosa*, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 75, pl. v. fig. 36.
,, *semipunctata*, Bailey, 1851, Smithsonian Contrib., vol. ii., art. 3, p. 11, figs. 17–19.
Rotalia roemeri, Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 240, pl. iv. fig. 52, *a.b.c.*
,, *mortoni*, Id. 1861, Ibid. vol. xliv. p. 337, pl. viii. fig. 1.
Planorbulina ungeriana, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 469, pl. xlviii. fig. 12.
,, *farcta*, var. *ungeriana*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 382, pl. xvi. figs. 23–25.
Truncatulina ungeriana, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 161, No. 10.

As figured by d'Orbigny, the test of *Truncatulina ungeriana* is comparatively thin, the faces unequally convex, and the peripheral edge attenuated or subcarinate. The drawing (Pl. XCIV. fig. 9) is not a good illustration of the species, the specimen being relatively thicker and altogether more stoutly built than the typical form.

Truncatulina ungeriana is moderately common in the North Atlantic and the Mediterranean, at depths of 90 to 600 fathoms; it occurs sparingly in the South Atlantic and off the Cape of Good Hope; and more or less characteristic specimens have been observed at seventeen Stations in the South Pacific, depth 37 to 2600 fathoms, and at one Station in the North Pacific, 2300 fathoms.

Fossil examples have been found in the London Clay, and in the middle and later Tertiaries of Central and Southern Europe.

Truncatulina robertsoniana, H. B. Brady (Pl. XCV. fig. 4, *a.b.c.*).

Truncatulina robertsoniana, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 65.

Test compressed, sublenticular; superior face slightly convex; inferior convex, more or less depressed at the umbilicus; peripheral edge subangular. Consisting of four or more convolutions, the whole of which are visible on the superior face, whilst on the inferior the last whorl conceals all preceding it except a small area in the centre. Segments very numerous, thirteen to fifteen in the final convolution; sutures marked by lines only, without superficial constriction. Colour rich brown, deepest near the middle of the test and at the sutural lines. Diameter, $\frac{1}{36}$th inch (0·7 mm.).

A handsome species, distinguished by its compressed contour, its very numerous segments and their regular disposition, and its deep brown colour. It has been named after one of the most diligent and successful of our marine zoologists, Mr. David Robertson, F.G.S., of Glasgow.

The finest specimens of *Truncatulina robertsoniana* are from two West Indian

Stations,—off Culebra Island, 390 fathoms; and off Sombrero Island, 450 fathoms; and at one point on the coast of South America, near Pernambuco, 675 fathoms. It occurs also at two "Porcupine" Stations in the North Atlantic, 1445 fathoms and 1476 fathoms; and was obtained by the Rev. A. M. Norman from two "Valorous" Stations in about the same latitude (55° N.), depths, 1450 fathoms and 1785 fathoms respectively.

Truncatulina tenera, n. sp. (Pl. XCV. fig. 11, *a.b.c.*).

Test regularly Rotaliform; both faces convex, peripheral edge acute and lobulated. Consisting of rather more than three convolutions of nearly equal width, the last of which is formed of five or six segments; sutures distinct, slightly depressed, marked on the superior face by nearly straight radial lines; aperture a curved fissure bordered by a thickened lip, situated at the inner margin of the final segment near the periphery. Diameter, $\frac{1}{55}$th inch (0·46 mm.).

I have had considerable hesitation in admitting this little Foraminifer to a position as an independent species, owing to its extreme resemblance to *Pulvinulina umbonata*, Reuss; but I am convinced by the passage forms with which it is found associated that the case is one of isomorphism, not of specific identity, and in this view I am supported by the opinion of Prof. Parker. The Planorbuline affinity of the test is often suggested by the aperture, which is generally furnished with a thickened lip or border; but though easily recognised amongst its congeners, it is impossible to name any single character by which the species can be distinguished with certainty from the isomorphous variety already referred to.

Truncatulina tenera is comparatively rare. It has been encountered at a single Station in the North Atlantic, off Gomera, Canaries, 620 fathoms; and at three Stations in the South Pacific, near the coast of Chili and Patagonia, 166 to 1375 fathoms.

Truncatulina dutemplei, d'Orbigny, sp. (Pl. XCV. fig. 5, *a.b.c.*).

Rotalina dutemplei, d'Orbigny, 1846, For. Foss. Vien., p. 157, pl. viii. figs. 19–21.
„ *affinis*, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 144, pl. xii. figs. 36–38.
Truncatulina dutemplei, Reuss, 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 160, No. 9.

Small *Truncatulinæ*, corresponding more nearly to *Truncatulina dutemplei*, d'Orbigny, than to any other recognised form, though by no means typical, occur at Station 323, South Atlantic, 1900 fathoms; and in the Pacific, north of Papua, 1070 fathoms.

Truncatulina dutemplei is a common fossil of the middle Tertiaries of Central Europe.

Truncatulina humilis, n. sp. (Pl. XCIV. fig. 7, *a.b.c.*).

Test rotaliform; the two faces nearly equally convex, peripheral edge thick and rounded; consisting of about three convolutions, of which the latest is composed of seven

or eight segments; septation indistinct externally; aperture an arched fissure at the inner margin of the final segment, near the periphery on the inferior side. Diameter, $\frac{1}{130}$th inch (0·2 mm.), often less.

An extremely obscure organism, characterised chiefly by its thick rounded contour and minute dimensions.

Truncatulina humilis is a deep-water form, tolerably abundant at a few localities. It has been obtained at three Stations in the North Atlantic, between lat. 24° and 40° N., depth from 1000 to 2750 fathoms; and at two in the North Pacific, between lat. 13° and 40° S., depth 1825 fathoms and 2350 fathoms respectively.

Truncatulina tumidula, n. sp. (Pl. XCV. fig. 8, *a.b.c.d.*).

Test trochoid, more or less depressed; consisting of three convolutions, the last of which is composed of about six segments; superior face highly convex; inferior less convex, slightly excavated at the umbilicus; peripheral edge thick and lobulated; segments inflated, especially those of the final convolution. Colour deep brown, except the terminal segment, which is generally of lighter hue. Diameter, $\frac{1}{130}$th inch (0·2 mm.).

I have been unable to identify the little shells on which the foregoing description is based with any previously recognised species. They vary a good deal in minor characters, but the minute dimensions, the thick and rounded general contour of the test, the ventricose segments, and the dark-brown colour are sufficiently uniform and distinctive.

The species is tolerably common in the red clay dredged at Station 5, south-west of the Canaries, depth 2740 fathoms, but has not been noticed elsewhere.

Truncatulina pygmæa, Hantken (Pl. XCV. figs. 9, 10).

Truncatulina pygmæa, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 78, pl. x. fig. 8.

The figures referred to on Pl. XCV. represent a minute variety of *Truncatulina* common in the deposits of deep areas, especially in the "red clay." The general contour of the test, its dimensions, and the disposition of the segments, are almost precisely those of *Truncatulina pygmæa*, Hantken; but owing to the greater thickness of the walls, the umbilical depression is filled up, and the sutures are marked by lines of clear shell-substance. These trifling differences are not such as to justify its treatment as an independent species, indeed they appear sufficiently accounted for by the deep-water habitat of the living specimens.

Truncatulina pygmæa occurs at three Stations in the North Atlantic, at depths of 2675 fathoms to 2750 fathoms; at two in the South Atlantic, 1900 fathoms and 2475

fathoms respectively; at two in the Southern Ocean, 1570 fathoms and 1950 fathoms; at ten in the South Pacific, 1450 fathoms to 2600 fathoms; and at five in the North Pacific, 1850 fathoms to 3125 fathoms.

The specimens described by Hantken were fossils from the Oligocene formations of Hungary.

Truncatulina rosea, d'Orbigny, sp. (Pl. XCVI. fig. 1, *a.b.c*).

Rotalia rosea, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 272, No. 7;—Modèle, No. 35.
Rotalina rosea, Id. 1839, Foram. Cuba, p. 87, pl. iii. figs. 9–11.
Planorbulina rosea, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 24, pl. iii. fig. 79.

A beautiful little Rotaline, conspicuous amongst littoral Foraminifera by its rosy hue, deepening almost to crimson at the centre of the spire.

Truncatulina rosea is a West Indian species, and has not been observed outside the comparatively narrow area originally indicated by d'Orbigny, namely,—the shores of Cuba, Martinique, Guadaloupe, St. Thomas, Jamaica, and Haiti. The figured specimen is from a gathering of littoral sand from Cuba, in which the species was particularly abundant.

Truncatulina præcincta, Karrer, sp. (Pl. XCV. figs. 1–3).

Rotalia præcincta, Karrer, 1868, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lvii. p. 189, pl. v. fig. 7.
„ „ Seguenza, 1879, Atti R. Accad. dei Lincei, ser. 3, vol. vi. pp. 56, 64, &c.

This is a thick, biconvex variety, the chief convexity of the shell being on the inferior side. The sutures are limbate externally, especially those radiating from the inferior umbilicus, which take the form of stout raised bands of clear shell-substance.

Truncatulina præcincta most affects the coral-reefs of the tropics. It has been met with off the Philippine Islands, 95 fathoms; and at five Stations amongst the islands of the South Pacific, at depths ranging from 15 to 255 fathoms. It also occurs in the Red Sea, 30 fathoms.

Karrer's specimens were Miocene fossils from Kostej, in the Banat; and the occurrence of the species in the Miocene and Pliocene of Southern Italy is recorded by Seguenza.

Truncatulina margaritifera, H. B. Brady (Pl. XCVI. fig. 2, *a.b.c.*).

Truncatulina margaritifera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 66.

Test Rotaliform; superior face slightly convex or nearly flat, inferior convex; peripheral edge sharp, subcarinate, more or less lobulated; consisting of three convolutions, of which the last has about twelve segments; segments all visible on the superior face,

only those of the final convolution on the inferior. Sutural lines on both faces marked by rows of exogenous beads of clear shell-substance, largest near the centre of the test; walls conspicuously foraminated. Diameter, $\frac{1}{20}$th inch (1·27 mm.).

An interesting and striking Foraminifer. Its nearest ally is *Truncatulina præcincta*, Karrer, from which it is distinguished by its thinner and slighter build, and by the beaded character of the sutural limbation.

Truncatulina margaritifera is common at Station 209, off the Philippine Islands, 95 fathoms; it occurs also off the New Hebrides, 125 fathoms; and on the coast of the Korea, 10 to 50 fathoms.

Truncatulina culter, Parker and Jones (Pl. XCVI. fig. 3, *a.b.c.*).

Planorbulina culter, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 421, pl. xix. fig. 1, *a.b.*
Anomalina bengalensis, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 259, pl. vii. fig. 111.

This form is described by Parker and Jones (*loc. cit.*) as "a neat, discoidal, biconvex, trochiform *Planorbulina*, showing on its upper face about twenty-five (often more) neatly set chambers in a compact spire, bordered with a thin keel, as wide as a whorl of the chambers." To these particulars may be added that the superior or spiral face is much less convex than the inferior, that the septal walls are thick and sometimes slightly limbate externally, and that the carina of the Challenger specimens is seldom quite so wide as laid down in the foregoing quotation.

Parker and Jones's specimens were from the "tropical Atlantic, 1080 fathoms." The Challenger gatherings furnish tolerably good examples from two Stations near the Canaries, 1125 fathoms and 1525 fathoms; from two in the South Atlantic, 675 fathoms and 1415 fathoms; and from three points amongst the islands of the South Pacific, 580 fathoms, 610 fathoms, and 1350 fathoms respectively.

Dr. Schwager states that his *Anomalina bengalensis*, which may be referred without hesitation to the same species, occurs at two horizons of the Pliocene formation of Kar Nicobar, and that it is still living on the shores of the Nicobar Islands.

Truncatulina rostrata, H. B. Brady (Pl. XCIV. fig. 6, *a.b.c.*).

Truncatulina rostrata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 65.

Test biconvex, subnautiloid, slightly asymmetrical; periphery sharp, subcarinate; consisting of two or three convolutions, of which only the outermost is visible externally. Segments numerous, about ten in the final whorl, equitant; sutures limbate on both faces of the test, especially near the centre, those of the later chambers more or less depressed as they approach the periphery. Normal aperture an arched labiate fissure, placed trans-

versely on the septal face of the terminal segment, close to the margin of the previous convolution, nearly median; adult shells have also a supplementary orifice, in the form of a vertical slit in the beak-like projection of the peripheral angle of the final segment. Walls coarsely perforated. Diameter, $\frac{1}{30}$th inch (0·84 mm.).

This is an exceedingly interesting modification of the Planorbuline type. The test is nautiloid, and the later segments of adult shells are furnished with two apertures, one at the inner margin, close to the edge of the previous convolution, the other at the distal or peripheral angle; so that in point of fact the species is isomorphous with both *Nonionina* and *Cristellaria*. The anomalous feature is the peripheral orifice; and this, though invariably present in fully formed specimens, does not make its appearance during the earlier stages of growth, indeed it has not been traced with any certainty before the last four or five segments. A similar abnormal condition has been observed in *Pulvinulina elegans*.

Truncatulina rostrata occurs on the northern shores of Papua, namely, in Humboldt Bay, 37 fathoms, and near the Admiralty Islands, 16 to 25 fathoms; and it has also been taken off Tongatabu, Friendly Islands, 18 fathoms.

Truncatulina reticulata, Czjzek, sp. (Pl. XCVI. figs. 5–8).

Rotalina reticulata, Czjzek, 1848, Haidinger's Naturw. Abhandl., vol. ii. p. 145, pl. xiii. figs. 7–9.
Siphonina fimbriata, Reuss, 1849, Denkschr. d. k. Akad. Wiss. Wien, p. 372, pl. xlvii. fig. 6, *a.b.*
„ *puteolana*, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 27, fig. 22, *A.B.C.*
Planorbulina reticulata, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 379.
Siphonina fimbriata, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 212, pl. iv. fig. 69.

In *Truncatulina reticulata* the Planorbuline lipped aperture presents an exaggerated development, generally taking the form of a short oval neck with everted edge; and the segments are bordered to a greater or less degree with a tubulated fringe, which forms a conspicuous marginal keel. The carinal tubuli of small specimens (fig. 7) are relatively large, and impart an irregularly serrate aspect to the periphery; in more fully grown examples (fig. 5) the marginal expansion presents a less broken outline; whilst shells of still larger dimensions (fig. 8) are characterised by a wide continuous keel with comparatively indistinct tubulation.

The species inhabits a somewhat wide geographical area. It has been noticed at various points in the Mediterranean, at depths of 100 to 360 fathoms; on the coast of Portugal, 50 fathoms; in the West Indies, 390 to 450 fathoms; and off Bermuda, 435 fathoms; off the coast of South America, near Pernambuco, 350 fathoms; on the southern shores of Australia, 38 fathoms; and at six Stations amongst the islands of the South Pacific, 17 to 410 fathoms.

Its geological distribution is limited to the Tertiary epoch. Specimens have been obtained from the Eocene deposits of the vicinity of Paris (Terquem), and from the London Clay bed of the Isle of Wight (Brady); from the Miocene of Austria (Czjzek, Reuss), of Southern Italy (Seguenza), of Malta, St. Domingo, and Costa Rica (Brady); and from the later Tertiaries of Italy (Costa, Seguenza, Terrigi), of Spain (Jones and Parker), and of Costa Rica (Brady).

Truncatulina soluta, H. B. Brady (Pl. XCVI. fig. 4, *a.b.c.*).

Truncatulina soluta, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 66.

Test elongate, compressed, biconvex; consisting of a number of inequilateral segments arranged on the Rotaliform plan, with the addition of two or three which project in a straight or curved line. Peripheral edge acute, furnished with a tubulated fringe or keel; surface more or less beset with tubercles, generally arranged in rows along the sutures. Aperture a curved fissure, on the median line, at the distal end of the terminal segment; furnished with a phialine rim or lip. Length, $\frac{1}{70}$th inch (0·36 mm.).

A minute crosier-shaped modification of *Truncatulina reticulata*, occurring off Culebra Island, West Indies, 390 fathoms; very rare.

Truncatulina echinata, H. B. Brady (Pl. XCVI. figs. 9–14).

Planorbulina echinata, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 69, pl. viii. fig. 31, *a.b.c.*

Test nearly spherical; consisting of about two convolutions, of which the outermost is composed of four segments; segments ventricose, unequally arched, embracing. Shell coarsely perforated and usually more or less beset with short, blunt, spines or tubercles. Aperture large and rounded; bordered by a thickened rim, or forming a short wide neck; often partially closed within by a shelly plate or septum. Diameter, $\frac{1}{80}$th inch (0·32 mm.).

This is a somewhat anomalous species in whatever light it is considered; but the wide, lipped, or neck-like aperture, the superficial ornament, and the general character of the shell suggest its affinity to *Truncatulina reticulata* and *Truncatulina soluta*, notwithstanding its dissimilar contour.

Truncatulina echinata has its home amongst the coral-sands of the Pacific and Indian Oceans. Notes have been kept of its occurrence at fourteen localities, of which three are referrible to the Indian Ocean, namely:—off Calpentyn, Ceylon, 2 fathoms; the Harbour of St. Louis, Mauritius; and the shore at Tamatavé, Madagascar: one to

the North Pacific,—off Honolulu Reefs, 40 fathoms: and the remaining ten to the islands of the South Pacific, 2 fathoms to 155 fathoms.

Anomalina, d'Orbigny.

Anomalina, d'Orbigny [1826], Bronn, Münster, Roemer, Reuss, Costa, Parker and Jones, Egger, Carpenter, Karrer, Seguenza, Brady, M. Sars, Schlicht, Siddall, Martonfi.
Planulina, d'Orbigny [1826], Bronn, Münster, Roemer, Reuss, Norman.
Rotalina, pars, d'Orbigny [1839].
Rosalina, pars, Reuss [1845], Stache.
Rotalia, pars, Reuss [1855], Stache, Gümbel.
Nonionina, pars, Reuss [1861].
Discorbina, pars, Reuss [1865], Seguenza.
Planorbulina, pars, Parker, Jones, and Brady [1865], Reuss, Wright.
Truncatulina, pars, Gümbel [1868], Hantken.

It is a debatable point whether much is gained in the long run by the retention of the term *Anomalina* for a small section of the *Planorbulinæ*. It was originally applied by d'Orbigny to two very different species of Foraminifera, one of which, *Anomalina punctulata*,[1] is a nearly equilateral, compressed, subnautiloid *Planorbulina*, umbonate at the inferior umbilicus; whilst the other, *Anomalina elegans*,[2] is a depressed plano-convex modification of *Discorbina*, with a sunken umbilicus.

In the "Vienna Basin" monograph, by the same author, four new species were introduced, all of which belong to the Planorbuline series. Of these, *Anomalina variolata* is obviously nothing more than the common *Truncatulina lobatula*, whilst the remaining three perhaps belong to *Anomalina* proper.

Parker and Jones (Phil. Trans., vol. clv. p. 383) state "the term *Anomalina* is not really wanted, however convenient it may be as a term for the subsymmetrical or somewhat biconvex arrested *Planorbulinæ*," and they subsequently direct attention to "the evident passage-forms from the plano-convex to the biconcave condition of the shell" as exemplified in *Anomalina coronata*.

Von Reuss, in his farewell contribution to the history of the Foraminifera, gives his views on the subject in a short paragraph, of which the following is a free version. "In the *Anomalinæ* the distinction between the spiral [superior] and the convex or umbilical side disappears to a greater or less extent. The nearly equilateral test assumes an apparently nautiloid character, the two sides presenting umbilical depressions of different width and depth. The aperture does not appear on the lateral surfaces, but is situated on the septal face of the chambers, though always nearer the flatter [superior] side. These forms pass through numerous gradual modifications into the typical *Truncatulinæ*, so that it is impossible to limit them sharply. The association of *Planorbulina*, *Trun-*

[1] *Ann. Sci. Nat.*, 1826, vol. vii. p. 282, No. 1, pl. xv. figs. 1–3.
[2] *Ibid.*, p. 282, No. 4;—Modèle, No. 42.

catulina and *Anomalina*, which are only conceived as subordinate divisions of a single group, is therefore completely justified."[1]

It is impossible from these definitions to draw any accurate idea as to what forms should be included in the sub-genus; nevertheless, from the figures of the various species that have been described, a series may be selected of which *Anomalina rotula*, d'Orb. (For. Foss. Vien., p. 172, pl. x. figs. 10–12) represents the extreme modification in one direction, and *Anomalina coronata*, P. and J., that in the other; the distinctive features of which are the nearly equilateral development of the test, and the more or less evolute character of both faces of the spire. In shape the forms referred to are either somewhat biconvex, nearly flat, or more or less biconcave; and in point of habit the shell is never adherent. It appears better that the term *Anomalina* should be restricted to the sub-symmetrical, partially evolute varieties, leaving to *Truncatulina* all those which are involute on either one or both sides. The most important additions to the series that this arrangement entails are *Planorbulina ammonoides*, a near approach to which is found in d'Orbigny's *Anomalina austriaca*, and *Planulina ariminensis*, which exemplifies the complanate modification of the same typical structure.

Anomalina ammonoides, Reuss, sp. (Pl. XCIV. figs. 2, 3).

Rosalina ammonoides, Reuss, 1845, Verstein. böhm. Kreid., pt. 1, p. 36, pl. xiii. fig. 66; pl. viii. fig. 53.
„ „ Id. 1850, Haidinger's Naturw. Abhandl., vol. iv. p. 36, pl. iv. fig. 2.
Nonionina bathyomphala, Id. 1862, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlvi. p. 95, pl. xiii. fig. 1, *a.b.*
Rosalina weinkauffi, Id. 1863, Ibid. vol. xlviii. p. 68, pl. viii. fig. 97.
„ *maorica*, Stache, 1864, Novara.-Exped., geol. Theil, vol. i. p. 282, pl. xxiv. fig. 32.
„ *orbiculus*, Id. Ibid. p. 285, pl. xxiv. fig. 34.
Planorbulina ammonoides, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 379.
Discorbina ammonoides, Reuss, 1865, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lii. p. 456, No. 5.
Rotalia capitata, Gümbel, 1868, Abhandl. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 653, pl. ii. fig. 92.
Rotalia ammonoides, Id., 1870, Sitzungsb. d. k. bayer. Akad. Wiss., p. 283.
Planorbulina (*Anomalina*) *ammonoides*, Jones and Parker, 1872, Quart. Journ. Geol. Soc., vol. xxviii. p. 106; table, p. 109.
„ *ammonoides*, Reuss, 1874, Das Elbthalgebirge in Sachsen, 2ter Theil, p. 114, pl. xxiii. fig. 9.

The nautiloid aspect of the test is perhaps a more constant and more noticeable feature of *Anomalina ammonoides* than of any other member of the group. The shell is generally much compressed, and nearly equally convex on the two sides; the peripheral edge is round, and the aperture is placed almost symmetrically in the median line. In certain characters, however, the species betrays a tendency to variation. Some specimens

[1] Das Elbthalgebirge in Sachsen, 1874, 2ter Theil, p. 113.

are depressed at both umbilici (fig. 3), others are umbonate at one or both (fig. 2); sometimes the earlier convolutions are visible to a nearly equal extent on both faces; sometimes, on the other hand, they are nearly involute on the inferior side, though the shell retains its bilateral symmetry, as in Reuss's figure. The coarse perforation of the shell-wall is usually more conspicuous on the inferior than on the superior face.

Good recent examples of *Anomalina ammonoides* were taken at a single Station in the North Atlantic, off Bermuda, 435 fathoms; but with this exception, so far as the Challenger collections are concerned, the record of its occurrence is limited to the South Pacific. The list comprises two localities near the Fiji Islands, depth 210 and 1350 fathoms respectively; another off the west coast of New Zealand, 275 fathoms; and a fourth in Humboldt Bay, Papua, 37 fathoms. It has been observed by Parker and Jones in soundings from the Red Sea, 372 to 678 fathoms; in anchor-muds from Bombay and Hong Kong, in shore-sands from Melbourne; and in material from the Abrolhos Bank, 260 to 940 fathoms. The *Rotalina lamarckiana* of d'Orbigny (Foram. Canaries, p. 131, pl. ii. figs. 13–15), which was obtained from sand collected on the shores of Teneriffe, is scarcely separable from the present species.

In the fossil condition it is common throughout the Cretaceous system; it is met with again in the London Clay, and identical or very closely allied forms occur in microzoic formations of almost every subsequent geological age.

Anomalina grosserugosa, Gümbel, sp. (Pl. XCIV. figs. 4, 5).

Truncatulina grosserugosa, Gümbel, 1868, Abhandl. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 660, pl. ii. fig. 104, *a.b.*
„ „ Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 74, pl. ix. fig. 6, *a.b.*
„ *granosa*, Id. Ibid., p. 74, pl. x. fig. 2, *a.b.c.*

The test of this species presents a smaller number of chambers in each convolution than that of its near ally *Anomalina ammonoides;* it is also relatively thicker and less regularly built. The walls are coarsely perforated, but have fewer pores on the superior than on the inferior side.

Recent specimens of *Anomalina grosserugosa* have been obtained at four Stations in the North Atlantic, the depths ranging from 450 to 1000 fathoms; at three Stations in the South Atlantic, 420 to 1415 fathoms; at two in the South Pacific, 610 and 2160 fathoms; and at two in the North Pacific, 345 and 2050 fathoms respectively.

As a fossil the form occurs in the Eocene of the Bavarian Alps (Gümbel), and of the London Basin (Brady); and in the *Clavulina-szabói* formation of Hungary (Hantken). D'Orbigny figures a very similar variety from the Miocene of Baden, near Vienna, under the name *Anomalina badenensis* (For. Foss. Vien., p. 171, pl. x. figs. 1–3).

Anomalina foveolata, n. sp. (Pl. XCIV. fig. 1, *a.b.c.*).

Test compressed, discoidal; superior face flat, somewhat concave near the umbilicus; inferior slightly convex; peripheral edge thick and rounded; consisting of three convolutions, the whole of which are more or less visible on both faces of the test; the final circuit composed of about nine segments; aperture an arched slit placed obliquely at the inner margin of the terminal chamber, close to the periphery of the previous convolution. Surface more or less areolated by exogenous shelly deposit, especially on the inferior side, which is also marked by limbate sutures. Diameter, $\frac{1}{40}$th inch (0·63 mm.), or more.

The evolute arrangement of the spire on both sides suggests the Anomaline affinity of this variety, though the two faces differ considerably in general aspect. Morphologically, fig. 1, *a*, corresponds to the superior or spiral face of the *Truncatulinæ*.

Not uncommon in shelly sand dredged off Bermuda, 435 fathoms.

Anomalina ariminensis, d'Orbigny, sp. (Pl. XCIII. figs. 10, 11).

Planulina ariminensis, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 280, pl. v. figs. 1–3 bis;—Modèle, No. 49.

,, *osnabrugensis* (?), Münster, 1838, Neues. Jahrb. für. Min., &c., p. 390, pl. iii. fig. 58.

Rosalina osnabrugensis, Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 243, pl. v. fig. 58, *a.b.c.*

Planorbulina ariminensis, Parker, Jones, and Brady, 1865, Ann and Mag. Nat. Hist., ser. 3, vol. xvi. p. 26, pl. iii. fig. 78.

Anomalina ariminensis is the explanate modification of the type, differing from *Anomalina ammonoides* in the extreme compression of the shell, its flattened sides and somewhat square peripheral edge, and the well-marked limbation of the sutures. The general conformation of the test resembles that of *Operculina* rather than *Nonionina*, its nearest isomorph being *Discorbina biconcava*, Parker and Jones.

Anomalina ariminensis is widely distributed in the North Atlantic, occurring both in the "Porcupine" and Challenger dredgings, at depths ranging from 150 to 1600 fathoms. It has been observed at two Stations in the South Atlantic, 350 fathoms and 2200 fathoms, at the former of which it is abundant and the specimens well-characterised, whilst at the greater depth it is very rare; also off the Cape of Good Hope, 150 fathoms, and at two points in the South Pacific, 155 and 275 fathoms respectively. It is common in the Mediterranean, at every depth to about 500 fathoms, as well as in the Adriatic. Parker and Jones have noted its presence on the Abrolhos Bank, 47 to 940 fathoms, and in Hong Kong Harbour.

As a fossil it has been found in the Chalk of England and elsewhere (Ehrenberg, Jones and Parker); in the middle and later Tertiaries of Germany (Roemer, Reuss), of

Central and Southern Italy, Sicily, and Spain (Jones and Parker, Seguenza), and of Costa Rica (Brady).

Anomalina coronata, Parker and Jones (Pl. XCVII. figs. 1, 2).

Anomalina coronata, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 294, pl. x. figs. 15, 16.

" " Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 469, pl. xlviii. fig. 13, *a.b.*

Planorbulina farcta, var. (*Anomalina*) *coronata*, Parker and Jones, 1865, Phil. Trans, vol. clv. p. 383, pl. xiv. figs. 7–11.

Truncatulina cristata, Gümbel, 1868, Abhandl. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 661, pl. ii. fig. 105, *a.b.*

The original description of this species runs as follows :—" The shell has the general aspect and bearing of the common *Truncatulina*, but it is not depressed, and affects a bilateral symmetry, the two surfaces being often nearly equal. The umbilici are deeply and broadly sunken, the convexity of the chambers forming an almost ridge-like corona on each face of the shell. The aperture is a transverse chink at the base of the chamber (as in *Nonionina*), being an extension of the slit-like aperture of *Truncatulina lobatula*, in accordance with the increased width of the chamber on the side which is undeveloped in the latter flattened form " (Parker and Jones, *loc. cit.*). It only remains to be added, that the test attains a diameter of about $\frac{1}{20}$th inch (1·26 mm.); and that the walls in some parts are coarsely porous, and in other parts become thickened with clear, imperforate, shelly deposit.

Anomalina coronata is very common in certain regions of the North Atlantic, especially between lat. 50° and 70° N.; and it also presents itself at several points in the temperate zone of the southern hemisphere, but its occurrence has only been noted at a single locality within the tropics. The following is a summary of its distribution :—ten " Porcupine " Stations in the North Atlantic, depths from 155 to 1630 fathoms ; four points on the coast of Norway, 30 to 160 fathoms (Parker and Jones); the Shetland Seas, 75 to 90 fathoms ; off the Azores, 450 fathoms ; and off the Canaries, 600 fathoms ;—in the South Atlantic, off Pernambuco, 350 fathoms ; off Tristan d'Acunha, 100 to 150 fathoms ; and north of the Falkland Islands, 1035 fathoms ;—in the Southern Ocean, off Prince Edward Island, 50 to 150 fathoms ;—and in the South Pacific, off the west coast of New Zealand, 275 fathoms ; and at three Stations amongst the islands on the western shores of Patagonia, 40 to 175 fathoms.

Parker and Jones state that the species " has been found in two deposits of the French Tertiaries "; Gümbel figures what is almost certainly the same form from the Eocene marls of the Bavarian Alps ; and Stache has described closely allied if not identical varieties from the Tertiary formations of New Zealand. Its occurrence in various deposits of later Tertiary age in Southern Italy is recorded by Seguenza.

Anomalina polymorpha, Costa (Pl. XCVII. figs. 3–7).

Anomalina polymorpha, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 252, pl. xxi. figs. 7–9.
Discorbina perforata, Seguenza, 1880, Mem. R. Accad. Lincei, ser. 3, vol. vi. p. 148, pl. xiv. fig. 3.

A large, coarse-shelled variety, scarcely so thick as *Anomalina coronata*, with radial extensions to some of the peripheral segments in the form of stout spines. It is isomorphous with *Pulvinulina spinimargo* and *Rotalia calcar*; but the contour of the test is very variable, and a certain number of non-spinous specimens, such as that represented in fig. 7, are almost invariably found associated with those of the normal spinous form.

Anomalina polymorpha has been taken at three Stations in the North Atlantic, namely:—off Bermuda, 435 fathoms; off Sombrero Island, 450 fathoms; and off Culebra Island, 390 fathoms: in the South Atlantic, off Pernambuco, 350 fathoms: in the Southern Ocean, off Prince Edward Island, 50 to 150 fathoms: and at three points in the South Pacific,—off Sydney, 410 fathoms; west of New Zealand, 275 fathoms; and off Kandavu, Fiji, 210 fathoms.

The species is figured both by Costa and Seguenza from fossil specimens found in the later Miocene or Pliocene marls of Reggio in Calabria.

Carpenteria, Gray.

Carpenteria, Gray [1858], Carpenter, Morris and Quekett, Carter, Moebius, Brady, Goës.
Dujardinia, Gray [1858].
Polytrema, pars, Carter [1876].
Raphidodendron, Moebius [1876].

The genus *Carpenteria* was established by the late Dr. J. E. Gray[1] for certain small Balaniform shells found adhering to various marine objects obtained from comparatively shallow water in warm areas. Owing to the presence of siliceous spicules in the interior of the chambers, it was at first believed that the organisms in question possessed intermediate characters, and formed a connecting link between the Foraminifera and the Sponges. The specimens described by Dr. Gray were subsequently submitted to Dr. Carpenter,[2] by whom the minute structure of the test was carefully investigated, and a position assigned to the genus in close proximity to *Globigerina*.

Somewhat later the supposed hybrid nature of the animal was called in question by Prof. Max Schultze,[3] who showed that the chambers of other adherent Foraminifera often contained siliceous spicules, the source of which was easily traceable to sponges with which the specimens had been accidentally associated; the conclusion of the author,

[1] *Proc. Zool. Soc. Lond.*, 1858, vol. xxvi. p. 266, woodcuts (*Carpenteria balaniformis*).
[2] *Phil. Trans.*, 1860, p. 564, pl. xxii.—Introd. Foram., 1862, p. 186, pl. xxi.
[3] *Wiegmann's Archiv für Naturg.*, 1863, Jahrg. xxix. p. 81, pl. viii.

based upon the structure and habit of the test, being that *Carpenteria* was a true Foraminifer, and in many ways nearly allied to *Polytrema*. The more recent researches of Mr. Carter[1] and Dr. Goës[2] have not only confirmed this view, but have enlarged our knowledge of the type in every direction, and the genus now includes a number of forms which display collectively a considerable diversity of external features.

Morphologically *Carpenteria* stands about midway between *Polytrema* and the Planorbuline genera (*Truncatulina* and *Rupertia*). The test is Rotaliform, adherent by its "superior" face, and more regularly constructed in its early than in its later development; the external contour is highly convex, subconical, or columnar; and the aperture, which is situated at or near the umbilical point of the terminal segment, occasionally takes the form of an extended tube. The chambers are comparatively few in number, and amongst the more typical species those of the outer whorls are irregularly spreading or buttress-like. The septal walls are generally though not invariably double, and, more rarely, the shell appears to possess a rudimentary or partially developed system of interseptal canals. Specimens occur either singly, or associated so as to form masses of considerable size.

At the earlier stages of growth the test of certain species is scarcely distinguishable from that of *Truncatulina lobatula* or *Truncatulina refulgens*, as may be seen from the young specimens (probably *Carpenteria monticularis* and *Carpenteria balaniformis*) represented in Pl. XCVIII. figs. 13–17, which exhibit decidedly Rotaline characters, not only with respect to the contour and arrangement of the segments, but also, though to a less degree, in the form and position of the orifice.

The genus *Carpenteria* is commonest within the tropics, but in the northern temperate zone it has been met with as far north as Bermuda (and the Mediteranean ?). The situations it most affects are coral seas of less depth than 200 fathoms, but it is occasionally found as low as 1000 fathoms. It is unknown in the fossil condition.

Carpenteria monticularis, Carter (Pl. XCIX. figs. 1–5).

Carpenteria monticularis, Carter, 1877, Ann. and Mag. Nat. Hist., ser 4, vol. xix., pl. xiii. figs. 9–12.

The test of *Carpenteria monticularis* in the very young stage resembles a somewhat depressed and spreading sessile *Truncatulina*, with very few (usually about four) visible segments. The aperture is not quite apical, but appears as a curved fissure on the inner umbilical margin of the final chamber a little within the summit. These characters are exemplified in fig. 5, and still better in the smaller specimen on fig. 1.

[1] *Ann. and Mag. Nat. Hist.*, 1876, ser. 4, vol. xvii. p. 187, pl. xiii.;—*Ibid.*, 1877, vol. xix. p. 209, pl. xiii.;—*Ibid.*, vol. xx. p. 68, woodcut, and p. 172.

[2] On the Reticularian Rhizopoda of the Caribbean Sea.—*Kongl. Svenska Vetenskaps-Akad. Handl.*, vol. xix. No. 4. This valuable contribution to our knowledge of tropical Foraminifera bears date 1882, but was not actually issued till November 1883, and was not received until these sheets were in the hands of the printer.

The adult shell is convex and monticular, and the circumference is deeply lobed or altogether irregular. The chambers are numerous, spirally arranged, long, spreading, broad and round at the outer margin, narrow at the umbilical end and of irregular outline; and their exposed faces are somewhat convex or inflated. The aperture is either a conspicuous rounded opening at the summit of the test, or an erect tubular extension of its apex. The tube when present is long and fragile, and is either simple or branched. In point of texture, the shell is thin, calcareous, hyaline, and finely porous.

Mr. Carter distinguishes this species from *Carpenteria balaniformis* by its comparative simplicity of structure, as evidenced in the absence of any "reticular framework in the substance of the chamber-walls"; and also by the uniform relatively fine perforation of the shell.

The figured specimens of *Carpenteria monticularis* are all from a single locality,—off Zamboanga, Philippine Islands, 102 fathoms. Others, though for the most part of small size and not so well characterised, were obtained at nine Challenger Stations, namely:—off New Hebrides, 125 fathoms; off Ki Islands, 129 fathoms; off Admiralty Islands, 16 to 35 fathoms; off Tahiti, 620 fathoms; off Raine Island, 155 fathoms; Honolulu Reefs, 40 fathoms; north of Falkland Islands, 1035 fathoms; off Ascension Island, 420 fathoms; and off Bermuda, 435 fathoms.

Carpenteria utricularis, Carter (Pl. XCIX. figs. 6, 7; Pl. C. figs. 1–4).

Polytrema utriculare, Carter, 1876, Ann. and Mag. Nat. Hist., ser. 4, vol. xvii. p. 211, pl. xiii. figs. 11–17.
Carpenteria utricularis, Id. 1877, Ibid. vol. xx. p. 176.

The original description of *Carpenteria utricularis* appears to have been founded upon young shells, presenting only a single sessile, inflated chamber with apical mouth. The specimens now figured (Pl. XCIX. and Pl. C.) have been recognised by Mr. Carter as belonging to the same species, and it will be seen from them that the general aspect of the adult shell does not differ materially from that of *Carpenteria monticularis*, either in the shape or disposition of the later segments or in point of size, though distinguishable by the texture and external reticulation of the walls.

The characters of the test in its earlier stages are well illustrated by the drawings (Pl. XCIX. figs. 6, 7, and Pl. C. fig. 1). The latter figure represents two individuals somewhat in the condition described by Mr. Carter,—flask-like chambers with a single terminal aperture. At a subsequent stage the ultimate and penultimate segments sometimes have independent apertures, as seen in figs. 6, 7. The succeeding chambers are larger and are arranged on the normal spiral plan, spreading at the margin so as to impart to the mature test a more or less conical contour. The aperture of the adult shell assumes various forms; it is sometimes a roundish or gaping orifice (fig. 3), sometimes a contracted bilabiate fissure (fig. 2), and sometimes, as described by Mr. Carter,

a delicate simple or branched tube projecting from the apex. In rare instances several of the segments of the same shell have independent tubular apertures. The walls of the test are thick, and the exterior strongly reticulated; the colour is generally greyish- or yellowish-brown. Fully-grown individuals attain a diameter of $\frac{1}{4}$th inch (6 mm.), or more.

The best Challenger specimens of *Carpenteria utricularis* are from the Admiralty Islands, 16 to 35 fathoms; but the species has also been found off Tongatabu, Friendly Islands, 18 fathoms, and off the coast of South America, near Pernambuco, 350 fathoms. Carter states that it is common in the West Indies, and on the shores of the Mauritius.

Carpenteria proteiformis, Goës (Pl. XCVII. figs. 8–14).

> *Carpenteria balaniformis*, var. *proteiformis*, Goës, 1882, Retic. Rhizop. Caribbean Sea (separate copy), p. 94, pl. vi. figs. 208–214, pl. vii. figs. 215–219.

I am indebted to the kindness of Dr. A. Goës for specimens of the polymorphic organism described by him under the name *Carpenteria balaniformis*, var. *proteiformis;* and their examination leaves little doubt that the form represented in Pl. XCVII. figs. 8–10, of which I had previously written a description under the impression that it was a new modification of the closely allied type *Rupertia*, belongs to the same species. The Challenger collections have afforded but few specimens, and they are for the most part from deeper water than those referred to by Dr. Goës. They are all, like the figures, few-chambered, and of columnar or irregularly cylindrical shape; and they furnish collectively a sort of intermediate group connecting *Carpenteria* and *Rupertia*. Dr. Goës, however, gives a series of examples with tests presenting a much wider diversity of contour and mode of construction,—conical, subglobular or ovate, linear and uniserial, irregular and branched, obscurely biserial, and even with chambers crowded together in an acervuline mass,—and their apertures are similarly variable.

The Challenger specimens have from three to six segments of inflated or subglobular form, often resembling those of a typical *Globigerina*. The aperture is situated in a stout tubular neck at the extremity of the terminal segment, the edge being sometimes neatly rounded, but more frequently broken or irregular. The sectional drawing (fig. 11) represents a specimen cut somewhat diagonally, to show the structure of the walls and the characters of the aperture. The shell is coarsely perforated, and in some cases a certain number of the pores remain open after the thickening of the wall has taken place, as shown in fig. 14; but, as a rule, the perforations are gradually filled up, and the exterior of the adult test is covered with strongly marked pits or punctations, occasionally of large size (figs. 12, 13).

The best examples were procured from the rich dredging off Culebra Island, West Indies, depth 390 fathoms; but the species occurs also at Station 33, off Bermuda, 435 fathoms, and at two points in the Eastern Archipelago, namely, Nares Harbour, Admiralty Islands, 17 fathoms, and off Raine Island, Torres Strait, 155 fathoms.

Rupertia, Wallich.

Rupertia, Wallich [1877], Bütschli, Brady, Schlumberger.

The genus *Rupertia* was established by Wallich for a number of Planorbuline Foraminifera obtained by him from near the coast of Greenland, during the cruise of the "Bulldog" in 1860. The morphological characters of the type, as well as the particulars of its geographical distribution, will be most easily discussed in connection with its single specific form.

Rupertia stabilis, Wallich (Pl. XCVIII. figs. 1–12).

Rupertia stabilis, Wallich, 1877, Ann. and Mag. Nat. Hist., ser. 4, vol. xix. p. 501, pl. xx.
„ „ Schlumberger, 1883, Feuille des Jeunes Naturalistes, ann. xiii. p. 27, pl. ii. figs. 6–8.

This interesting organism forms the subject of a short paper by Dr. Wallich,[1] which contains, in addition to the author's account of the species, a note by Profs. Rupert Jones and Parker on its structure and affinities. The specimens on which the descriptions are based appear from the drawings to have been somewhat obscure, and their structural features not so well marked externally as those of many which have since been obtained; nevertheless the essential characters of the species are correctly stated, and the points left for further elucidation are comparatively few, and only such as can now be satisfactorily cleared up. It has recently been well figured by Schlumberger (*loc. cit.*).

In its typical presentment the test of *Rupertia stabilis* has the form of a straight, curved, or inequilateral column, with a slightly expanded discoidal base and a swollen head. The length of the columnar portion, and the shape and relative size of the capitulum vary in every specimen. The external contour of many of the shells is aptly suggested by the terms "an irregular lumpy outline, like some of the asymmetrical Puff-balls, and somewhat resembling an inverted *Ascidia mamillata*" (Wallich, *op. cit.*, p. 502), whilst that of others is more regular and more distinctly spiral.

During the early stages of growth the shell is very similar in form and habit to an ordinary adherent Rotalian such as *Truncatulina refulgens*, as may be seen from the young specimen represented in fig. 1. The base, however, attains its full width upon the completion of a single convolution, and the later coils are superimposed vertically, each only slightly embracing its predecessor. After the second convolution the diameter begins to increase; in some cases the third widens suddenly and forms a bulbous end to the shell, in others the increase is more gradual. The adult test may have as many as five convolutions, but more commonly the number is less.

The adherent base forms a slightly expanded flat or concave disk, on which, under

[1] On *Rupertia stabilis*, a new sessile Foraminifer from the North Atlantic, *loc. cit.*

favourable circumstances, the segmentation of the first convolution may be distinctly traced (fig. 8). There are usually about five segments in each convolution; they are convex or inflated externally, and the sutures are strongly marked. In large specimens it frequently happens that the inner margins of the segments of the terminal whorl do not meet, but leave a deep umbilical hollow, as seen in figs. 6 and 9. The aperture is an arched slit at the inner edge of the final chamber, at or near the line of union with the previous convolution. The walls are thick, and, except near the base of the test, coarsely perforated. The length of adult specimens is sometimes $\frac{1}{15}$th inch (1·68 mm.), or even more.

It is obvious that, from a morphological point of view, the base of the test corresponds with the superior or spiral face of the typical Rotalian shell, the successive whorls being added vertically, that is to say, on the summit of those previously formed, instead of laterally, at the circumference.

The foregoing description is drawn from well-grown typical specimens, of which the series figured in Pl. XCVIII. furnishes good examples. But the species presents considerable range of variation, and a large proportion of the specimens from some localities have the opaque shells and comparatively obscure external characters delineated in the original drawings; and this is often accompanied by defective segmentation. Occasionally the shell is incrusted with extraneous bodies, such as sand, sponge-spicules, and the like—a not uncommon feature in some of the Planorbuline genera; and sometimes the mouth is crowded with sponge-spicules, as frequently seen in *Polytrema* and *Carpenteria*.

Rupertia stabilis has its home in the northern portion of the North Atlantic. A few scattered examples have been found in the southern hemisphere, but it has never been taken within the tropics, nor indeed within about 35° north or south of the equator. The figured specimens are all from a single point in the "cold area" of the Faröe Channel, depth 632 fathoms, where the species exists in extraordinary abundance. Those collected by Dr. Wallich were from "three soundings taken on opposite sides of the southern extremity of Greenland—the depth in the three localities varying from 108 fathoms on the east coast, to 1205 fathoms on the west." The species occurs at thirteen "Porcupine" Stations and one Challenger Station in the North Atlantic,—the latter, off the Azores, being the most southerly—the depth ranging from 5 fathoms on the Rockall Bank, to 1360 fathoms. Poor examples have been met with in dredgings from off the Cape of Good Hope, 150 fathoms, north of the Falkland Islands, 1035 fathoms, and in the South Pacific, near Juan Fernandez, 1375 fathoms. Schlumberger's specimens were from the Bay of Biscay.

Pulvinulina, Parker and Jones.

Nautilus, pars, Soldani [1780], Fichtel and Moll.
Serpula, pars, Montagu [1808].
Cidarollus, *Eponides*, *Cancris*, Montfort [1808].
Pulvinulus, pars, Lamarck [1816].

Cristellaria, pars, Lamarck [1822].
Placentula, pars, Lamarck [1822], Berthelin.[1]
Crepidulina, pars, Blainville [1824].
Rotalites, pars, Blainville [1824].
Rotalia, pars, d'Orbigny [1826], Reuss, Parker and Jones, Morris and Quekett, Karrer, Schwager, Gümbel.
Rosalina, pars, d'Orbigny [1826], Parker and Jones, Gümbel, Terquem.
Turbinulina, pars; *Planorbulina*, pars, d'Orbigny [1826].
Omphalophacus, Ehrenberg [1838].
Rotalina, pars, d'Orbigny [1839], Reuss, Czjzek, Bailey, Ehrenberg, Bornemann, Egger, Williamson, Karrer, Seguenza, Alcock, Terquem, Parfitt, Schlicht, Schlumberger.
Valvulina, pars, d'Orbigny [1839], Terquem.
Gyroidina, Roemer [1840].
Planulina, pars, Roemer [1840], Ehrenberg.
Platycæcus, *Spiropleurites*, Ehrenberg [1854].
Pulvinulina, Parker and Jones [1862], Carpenter, Brady, S. Owen, Reuss, Karrer, M. Sars, Hantken, G. M. Dawson, Fischer, Miller and Vanden Broeck, Schulze, Norman, Blake, Wright, Siddall, Terrigi, &c.
Discorbina, pars, Schwager [1866], Seguenza.
Truncatulina, pars, Karrer [1868], Seguenza.
Epistomina, Terquem [1883], Uhlig.

Of all the Rotaline genera *Pulvinulina* presents the greatest range of morphological variation. It is impossible to summarise the characters of the genus in the terms of a brief zoological description, or even to seize upon distinctive features sufficiently constant to serve under all circumstances for its separation from allied or collateral groups. It is only by the study of its various modifications in series and in relation to a central type, after the method pursued by Parker and Jones and Carpenter, that any adequate knowledge of its multiform aspects can be obtained. The *Nautilus repandus* of Fichtel and Moll exemplifies, perhaps, the most characteristic features of the group, and with a sufficient array of specimens it is easy to demonstrate that the simple *Spirillina*-like investment of *Pulvinulina vermiculata* and the complex *Nummulina*-like shell of *Pulvinulina elegans* or

[1] M. Berthelin prefers Lamarck's appellation, *Placentula*, for the present genus, and has on more than one occasion defended its employment on the ground of priority, basing his argument on the occurrence of the term in the Extrait du Cours de Zoologie du Muséum d'Histoire Naturelle.

Lamarck's connection with the genus is as follows. In the Extrait du Cours, &c., 1812, p. 122, the word, "*Placentule*" appears, together with *Rotalie* and *Lenticuline*, in the category of the 5th section of "Céphalopodes testacés polythalames," just as *Discorbis* occurs in a subsequent list; but without either description, figures, or any other indication of zoological characters. It is manifest that the employment of an indefinite vernacular name in this way has no bearing whatever on a question of systematic nomenclature.

In the Tableau Encycl. et Méthod., &c., 1816, pl. cccclxvi. figs. 9, 10, Lamarck has copied Fichtel and Moll's drawings of *Nautilus repandus* and *Nautilus asterizans*, appending to them the names *Pulvinulus repandus* and *Pulvinulus asterizans* respectively; and in the Hist. Nat. des Anim. sans Vert., vol. viii. (1822) p. 621, he describes the same forms as *Placentula pulvinata* and *Placentula asterizans*.

According to modern ideas, the figures indicated represent the types of two very distinct genera of Foraminifera, *Pulvinulina* and *Nonionina*; and were there any ground for coupling one of Lamarck's names with the former, the other must perforce take precedence for the latter genus. But no such authority exists, and it has been tacitly admitted that, by the adoption of the generic terms *Pulvinulina*, *Discorbina*, *Rotalia*, &c., in their rearrangement of the ROTALINÆ, Messrs. Parker and Jones have taken the course least open to objection, and have at the same time sufficiently recognised the earlier Lamarckian nomenclature.

Pulvinulina partschiana represent only the extreme development in two opposite directions of an unbroken series of which that species occupies the central position. The sequence of minute morphological changes which the series reveals has been indicated with more or less detail by the authors already referred to; and, though the Challenger collections contribute not a little to our knowledge of the subject, it is scarcely needful to repeat with greater minuteness what has already been clearly and effectively stated.[1]

With few exceptions, the shells of the *Pulvinulinæ* are constructed on the Rotaliform plan, but they assume every variety of contour, from the conical, with flat inferior face (*Pulvinulina procera*), to the reverse condition, in which the superior face is flat and the inferior convex or conical (*Pulvinulina micheliniana*); the intermediate forms being more or less biconvex (*Pulvinulina repanda*). A few of the weaker modifications become evolute and present a thin outspread shell (*Pulvinulina pauperata*). The shape of the test is further diversified by the greater or less rapidity of the progressive increase of the size of the chambers, which determines its relatively circular (*Pulvinulina karsteni*) or oblong (*Pulvinulina auricula*) peripheral outline. The umbilicus is either closed by the meeting of the inner margins of the chambers (*Pulvinulina repanda*), or deeply sunk (*Pulvinulina micheliniana*), or the cavity is filled up with exogenous deposit (*Pulvinulina elegans*). The shell-wall is very finely porous, the tubulation being more minute and delicate than in any of the allied Rotaline genera. The septal walls are always single, and there is no evidence of even a rudimentary canal system. The exterior of the test is usually smooth; occasionally it is hispid, granular, or rugose, or beset with raised beads or tubercles; but for the most part any exogenous deposit takes the form of external thickening or limbation of the sutures and chamber-margins, especially on the inferior side of the test.

Parker and Jones divide the genus into a number of subordinate groups, based chiefly upon the relative prominence and degree of development of the various features above enumerated, taking into account also the bathymetric range of the constituent species. The five divisions they propose are typified by *Pulvinulina repanda*, *Pulvinulina auricula*, *Pulvinulina menardii*, *Pulvinulina schreibersii*, and *Pulvinulina elegans* respectively. The details of the classification are open to some objections, but on the whole it affords as convenient a framework as can be devised for the arrangement of a long and otherwise unmanageable series of forms. According to this scheme, the recent species described in the present Report are apportioned as follows:—The depths, which are quoted from Parker and Jones's synopsis, require considerable revision.

I. "The type or *repanda* group; 10–100 fathoms."
Pulvinulina repanda, *P. concamerata*, *P. punctulata*, *P. concentrica*, *P. vermiculata*, and *P. dispansa*.

[1] Parker and Jones, *Phil. Trans.*, vol. clv. p. 390.—Carpenter, Introd. Foram., p. 210.

II. "The *auricula* or *oblonga* group; 10–500 fathoms (70 fathoms best)."
Pulvinulina auricula, P. oblonga, P. scabra, P. hauerii, and *P. lateralis.*

III. "The *menardii* or abyssal group; 100–2700 fathoms."
Pulvinulina menardii (and var. *fimbriata*), *P. tumida, P. canariensis, P. patagonica, P. crassa, P. micheliniana, P. umbonata, P. exigua,* and *P. pauperata.*

IV. "The *schreibersii* or stellar group; 30–2700 fathoms."
Pulvinulina schreibersii, P. procera, and *P. karsteni.*

V. "The *elegans* or strongly limbate group; 70–1000 fathoms."
Pulvinulina elegans, P. partschiana, P. berthelotiana, and *P. favus.*

The geographical distribution of the genus is world-wide. Living specimens have been taken in the Arctic Ocean up to the very farthest points hitherto explored, and in the southern hemisphere to the Antarctic Ice-barrier; and at every intermediate latitude the type is copiously represented. Certain species have a more or less pelagic existence, either at the surface of the ocean or in mid-water, but the majority of forms inhabit the bottom-ooze, and their bathymetrical range extends from the littoral or algal zone down to a depth of 3125 fathoms. In point of numerical abundance, the specimens of *Pulvinulina* far exceed those of any other genus of recent Foraminifera, *Globigerina* alone excepted; and their dead shells, especially those of the pelagic species, contribute in like proportion to the formation of oceanic deposits.

The geological history of the genus commences in the Carboniferous period, the earliest known *Pulvinulinæ* being rare specimens pertaining to the "*elegans*" group, which occur in the Calcaire de Namur of Belgium. Very similar forms have been found in the Trias of St. Cassian and of Derbyshire, in the Lias, and the Oolite. The Cretaceous age is marked by a large increase in the number of species, and the list receives constant accessions during the successive stages of the Tertiary epoch.

Pulvinulina repanda, Fichtel and Moll, sp. (Pl. CIV. fig. 18, *a.b.c.*).

Nautilus repandus, Fichtel and Moll, 1803, Test. Micr., p. 35, pl. iii. figs. *a.d.*
Rotalia repanda, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 175, No. 25.
Pulvinulina repanda, Carpenter, 1862, Introd. Foram., p. 210.
Placentula repanda, Berthelin, 1878, Foram. de Bourgneuf et Pornichet, p. 41, No. 68.
Pulvinulina repanda, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 206, pl. iii. fig. 61.

The *Nautilus repandus* of Fichtel and Moll has been adopted by Parker and Jones as the central type of the genus *Pulvinulina.* The original figure (*loc. cit.*) is that of a regularly Rotaliform shell, the two faces of which are nearly equally convex, presenting

little or no umbilical depression, and with an angular, somewhat limbate or bordered periphery. The segmentation of the superior side is not apparent, otherwise the specimen is very similar to that portrayed in Pl. CIV. fig. 18.

The typical *Pulvinulina repanda* is a shallow-water Foraminifer, tolerably common in almost every part of the world except the Arctic seas, most abundant in tropical and subtropical latitudes. Its home extends from the littoral zone down to about 200 fathoms; but it has been found sparingly at two Stations in the North Atlantic with depths of 435 fathoms and 1000 fathoms respectively.

As a fossil it has been identified in the middle and later Tertiary formations of Italy (Parker and Jones, Seguenza).

Pulvinulina repanda, var. *concamerata*, Montagu, var. (Pl. CIV. fig. 19, *a.b.c.*).

Serpula concamerata, Montagu, 1808, Test. Brit., Suppl., p. 160 (*fide* Williamson).
Rotalina concamerata ("mature"), Williamson, 1858, Rec. For. Gt. Br., p. 52, pl. iv. figs. 102, 103.
Pulvinulina repanda, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.

The specimens figured by Williamson under the name *Rotalina concamerata*, are referrible to two distinct species of Foraminifera. One of them, supposed to be the "young" condition, is the common *Discorbina globularis*; the other, the "mature" shell, is a variety of *Pulvinulina repanda*, distinguished from the type by the comparatively slight convexity of the inferior side, and the more conspicuous limbation of the sutures on the superior face.

Pulvinulina repanda, var. *concamerata* is not uncommon at depths of 20 to 150 fathoms, on the shores of Great Britain, Belgium, and France, and is found as far north as the Faröe Channel.

Pulvinulina punctulata, d'Orbigny, sp. (Pl. CIV. fig. 17, *a.b.c.*).

Rotalia punctulata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 273, No. 25;—Modèle, No. 12.
Rosalina vesicularis (pars), Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 292, pl. x. figs. 22–24.
Pulvinulina repanda, var. *punctulata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 394, pl. xiv. figs. 12, 13.
„ *punctulata*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 20, pl. iii. fig. 82.
„ *repanda*, Jones, Parker, and Brady, 1866, Monogr. Foram. Crag, pl. ii. figs. 22–24.

A depressed modification of *Pulvinulina repanda*, with more or less inflated segments and excavated non-limbate sutures; the inferior umbilical region somewhat

sunk, and usually marked by a number of conspicuously large perforations, sometimes by a few exogenous warts or tubercles. It is one of the largest of Rotaliform Foraminifera, specimens often attaining a diameter of $\frac{1}{6}$th inch (4 mm.), or even more.

With the exception of a single point on the west coast of Patagonia, at which one or two small examples have been obtained, the known geographical distribution of *Pulvinulina punctulata* is limited to the North Atlantic, the Mediterranean, and the Adriatic. The large shell figured in Pl. CIV. is from Station 24, off Culebra Island, West Indies, 390 fathoms. The species has been collected off the Canaries, and at the "Porcupine" Station No. 25 (1869), depth 164 fathoms; and it is tolerably abundant off the coast of Norway, at depths of 60 to 200 fathoms.

Fine examples have been found in the Crag of Sutton, near Colchester (Jones, Parker, and Brady), in the Pliocene of Southern Italy (Seguenza), and in the Post-tertiary beds of Norway (Crosskey and Robertson).

Pulvinulina concentrica, Parker and Jones (Pl. CV. fig. 1, *a.b.c.*).

"Hammoniæ subconicæ tuberculatæ seu tuberosæ," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 56, pl. xxxvii. fig. *B*.

Pulvinulina concentrica (P. & J., Ms.), Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 470, pl. xlviii. fig. 14.

„ „ Parker and Jones, 1865, Phil. Trans., vol. clv. p. 393.

Discorbina vestita, Seguenza, 1880, Mem. R. Accad. dei Lincei, ser. 3, vol. vi. p. 148, pl. xiii. fig. 39.

So far as I am aware, there is no published description of the present species, except a brief note by myself on some specimens dredged off Shetland (*loc. cit.*); but the manuscript name applied by Parker and Jones to one of Soldani's figures has been generally accepted.

The test of *Pulvinulina concentrica* resembles that of *Pulvinulina punctulata* in its depressed contour and in the form of the segments, its peculiar and very characteristic feature being a broad band of clear exogenous shell-substance bordering the chambers and concealing, to greater or less extent, their lateral faces.

Pulvinulina concentrica occurs at two Challenger Stations in the North Atlantic, namely, off Bermuda, 435 fathoms, and west of the Azores, 1000 fathoms; also, off Shetland, 75 to 90 fathoms; in the Faröe Channel, 155 fathoms; and off the coast of Norway, 15 to 40 fathoms; in the Bay of Biscay, and in the Mediterranean. The South Atlantic has furnished specimens from off Tristan d'Acunha, 100 to 150 fathoms; and the South Pacific, from off Kandavu, 210 fathoms; and off Raine Island, 155 fathoms.

Under the name *Discorbina vestita*, Seguenza has figured an unmistakable specimen of this species, obtained from the Miocene formation of Southern Italy.

Pulvinulina dispansa, n. sp. (Pl. CXV. fig. 3, *a.b.*).

Test adherent (or free?), spreading, outline irregularly lobulated; composed of numerous segments of various sizes and shapes, arranged in an obscure, depressed, irregular, Rotaliform spire. Superior surface beset with minute exogenous beads or tubercles; inferior smooth, coarsely perforated. Aperture indistinct. Diameter, $\frac{1}{6}$th inch (4 mm.), or more.

I am indebted to Mr. James Yate Johnson for specimens of this fine species, which were taken from a coral (*Dendrophylla cornigera*) dredged by him on the coast of Madeira. Its nearest ally is *Pulvinulina punctulata*, of which it is perhaps a wild-growing modification; but the mode of growth suggests affinity also to *Pulvinulina vermiculata*.

The figured specimen is from Madeira. Mr. Murray has somewhat similar but less irregular examples from Station 24, off Culebra Island, West Indies, 390 fathoms.

Pulvinulina vermiculata, d'Orbigny, sp. (Pl. CXV. fig. 2, *a.b.*).

"*Placentulæ*," Soldani, 1795, Testaceographia, vol. i. pt. 3, p. 237, pl. clxi. figs. *A.B.C.*
Planorbulina vermiculata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 280, No. 3.
Rotalia vermiculata, Jones and Parker, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 305, No. 116.
Pulvinulina vermiculata, Carpenter, 1862, Introd. Foram., p. 211, pl. xiii. figs. 4–6.
„ „ Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 178, pl. xii. fig. 146.
Planorbulina eocæna, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. p. 90, pl. ix. fig. 15, *a.b.*

Pulvinulina vermiculata has a thin outspread shell, normally adherent. The earlier chambers are small and are arranged in a more or less distinct depressed spire; but the principal part of the test consists of a *Spirillina*-like tube of uneven width, subdivided at very irregular intervals. Sometimes the spire is broken up and the chambers form irregular annuli. The free surface of the test (fig. 2, *a*) is finely porous, whilst on the attached face (fig. 2, *b*) the perforations are less numerous but of comparatively large size. The true affinity of this species is by no means apparent at first sight, but its connection with the more typical *Pulvinulinæ* is established by intermediate gradational forms.

Pulvinulina vermiculata is not uncommon in the shallow-water margins of the Mediterranean. Soldani has the following note as to its occurrence:—"Reperiuntur in fundo maris ad Portum Ferrar[ium] et Liburn[ensem], et quidem copiosè, ut patet ex hoc vasculo, in quo 1662 continentur sub pondere granorum sex," *loc. cit.*

There can be little doubt that Terquem's *Planorbulina eocæna*, obtained from the Eocene formations of Paris, belongs to the present species; its close affinity is admitted by the author.

Pulvinulina auricula, Fichtel and Moll, sp. (Pl. CVI. fig. 5, *a.b.c.*).

Nautilus auricula, var. *a*, Fichtel and Moll, 1803, Test. Micr., p. 108, pl. xx. figs. *a.b.c.*
Valvulina excavata, d'Orbigny, 1839, Foram. Canaries, p. 137, pl. i. figs. 43–45.
Pulvinulina auricula, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 393.
„ *contraria*, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 490, No. 3;—Schlicht, 1870, Foram. Pietzpuhl, pl. xxii. figs. 10–13.
Valvulina ovalis, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III., p. 103, pl. xi. fig. 10.

Pulvinulina oblonga, Williamson, sp. (Pl. CVI. fig. 4, *a.b.c.*).

Nautilus auricula, var. *β*, Fichtel and Moll, 1803, Test. Micr., p. 108, pl. xx. figs. *d.e.f.*
Rotalina oblonga, Williamson, 1858, Rec. For. Gt. Br., p. 51, pl. iv. figs. 98–100.
Pulvinulina repanda, var. *auricula*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.

The typical *Pulvinulina auricula* has an elongate-ovate test, the two lateral faces of which are nearly equally convex; the oblong contour being the result of the very rapid increase in length of the successive chambers. The septal face of the final segment is inflated, and the inner margin is generally extended so as to form a sort of flap, which overlaps and conceals the inferior umbilical ends of the earlier segments. The periphery of the test is entire, the sutures being marked by fine lines, without either limbation or depression.

The variety named by Fichtel and Moll *Nautilus auricula*, var. *β*, and by Williamson *Rotalina oblonga*, differs from the foregoing in having somewhat ventricose segments, slightly depressed and faintly limbate sutures, and subcarinate periphery. Specimens in which these features are well marked are readily distinguished from the more typical forms, nevertheless it is impossible to separate them as a group, except by comparative and very variable characters.

To judge from living specimens (Pl. LIV. fig. 18), Reuss's original drawings of *Rotalia contraria* (Zeitschr. d. deutsch. geol. Gesellsch., 1851, vol. iii. pl. v. fig. 37) represent a somewhat anomalous Rotaliform modification of the genus *Bulimina*; whilst the forms figured by von Schlicht (*loc. cit.*), to which the same specific name has been assigned, appear to be true *Pulvinulinæ* of the "*auricula*" type.

The *Rotalina brongniartii* of d'Orbigny (For. Foss. Vien., p. 158, pl. viii. figs. 22–24), and the *Valvulina cordiformis* of Costa (Atti dell' Accad. Pont., vol. vii. p. 262, pl. xxi.

fig. 10 = *Pulvinulina cordiformis*, Reuss) are also closely related to the present species, furnishing the intermediate links which connect *Pulvinulina auricula* with *Pulvinulina hauerii*.

Pulvinulina auricula and its immediate allies are common in the North Atlantic from the littoral zone down to 200 fathoms, and occasional specimens are met with at depths of 500 fathoms or even more. They occur also in the Mediterranean, the Red Sea, off the Cape of Good Hope, and on the shores of Madagascar; at one Station in the North Pacific, 95 fathoms, and at eight in the South Pacific, 17 to 275 fathoms.

In the fossil condition their range is limited to the Tertiary and Quaternary epochs,—from the Eocene of the Paris Basin to the Post-tertiary formations of Italy, Canada, and elsewhere.

Pulvinulina oblonga, var. *scabra*, nov. (Pl. CVI. fig. 8, *a.b.c.*).

The general contour of the test, and the form and disposition of the segments, similar in all respects to those of *Pulvinulina oblonga*. Sutures and periphery more or less limbate; surface rugose or granular on the superior side, smooth on the inferior. Length, $\frac{1}{50}$th inch (0·5 mm.).

This is a small rugose variety, which has been met with off Bermuda, at a depth of 435 fathoms; west of the Azores, 1000 fathoms; at three points on the shores of Papua, 17 to 155 fathoms; and off the Philippines, 95 fathoms.

Pulvinulina lateralis, Terquem, sp. (Pl. CVI. figs. 2, 3).

Rosalina lateralis, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i., Mém. III., p. 25, pl. ii. fig. 11, *a.b.c.*

An intermediate modification, nearly allied to *Pulvinulina auricula*, but partaking also of the characters of the typical *Pulvinulina repanda*. The contour of the test is proportionately broader than that of the former species, the outline of the segments on the superior side more arched and their progressive increase in size not so rapid. The septal face of the final chamber, which frequently occupies fully half the inferior side of the shell, is much inflated and coarsely perforated, the pores being round or irregular and sometimes bordered by a thickened rim.

Pulvinulina lateralis affects the shallow margins of tropical and subtropical seas. It has been observed at eight localities amongst the islands of the Pacific, but in no case at greater depth than 28 fathoms; in the Gulf of Suez, 15 fathoms; and in shore-sands from Algoa Bay and Madagascar.

It was found by Terquem amongst the microzoa of the Pliocene deposits of the Island of Rhodes.

Pulvinulina hauerii, d'Orbigny, sp. (Pl. CVI. figs. 6, 7).

Rotalina hauerii, d'Orbigny, 1846, For. Foss. Vien., p. 151, pl. vii. figs. 22–24.
Pulvinulina hauerii, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 393.
„ *budensis*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv., pl. ix. fig. 5 (*Pulvinulina brongniarti*, at p. 78).

This species also belongs to the "*auricula*" group of *Pulvinulinæ*. It is distinguished from the rest of the series by its less elongate contour and thick rounded peripheral edge.

The Challenger collections furnish examples of *Pulvinulina hauerii* from seven points in South Pacific, the recorded depths of which vary from 17 to 620 fathoms. A single specimen was also taken off Palma, Canaries, 1125 fathoms.

As a fossil it occurs in the Miocene of the Vienna Basin (d'Orbigny, Reuss), in the Salt-clay of Wieliczka (Reuss), and in the Upper Pliocene of the Island of Rhodes (Terquem). Hantken's drawing (*loc. cit.*) represents a somewhat thinner shell, but otherwise closely resembles Pl. CVI. fig. 6; if I am correct in attributing it to the present species, the geological range extends back to the Oligocene period.

Pulvinulina menardii, d'Orbigny, sp. (Pl. CIII. figs. 1, 2).

Rotalia menardii, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 273, No. 26;—Modèle, No. 10.
Rotalina cultrata, Bailey, 1851, Smithsonian Contrib., vol. ii., art. 3, p. 11, figs. 14–16.
Planulina incurvata, Ehrenberg, 1854, Mikrogeologie, pl. xxvi. fig. 42.
„ *membranacea*, Id. Ibid. pl. xxvi. fig. 43.
Pulvinulina repanda, var. *menardii*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 394, pl. xvi. figs. 35–37.
Discorbina saccharina, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 257, pl. vii. fig. 106.
Pulvinulina menardii, Owen, 1867, Journ. Linn. Soc. Lond., vol. ix., Zool., p. 148, pl. v. fig. 16.
Rosalina asterites, Gümbel, 1868, Abhandl. d. k. bayer. Akad. Wiss., II. Cl., vol. x. p. 658, pl. ii. fig. 101, *a.–c.*
Pulvinulina menardii, var. *cultrata*, Vanden Broeck, 1876, Ann. Soc. Belg. Micr., vol. ii. p. 141, pl. iii. figs. 13, 15.
„ *menardii*, Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 80.

In Parker and Jones's arrangement of the genus, *Pulvinulina menardii* serves as the type of a considerable group of species, which includes, amongst others, all those hitherto found living at the surface of the ocean.

The external characters of the typical form are well embodied in d'Orbigny's Modèle,

No. 10, which represents a compressed, regular, neatly constructed, Rotaline shell, with subcarinate, slightly lobulated periphery. It is composed of about two convolutions, the outermost consisting of six segments; the sutures are limbate on the superior side, more or less depressed on the inferior. Good examples have often a diameter exceeding $\frac{1}{20}$th inch (1·27 mm.).

Commencing with the comparatively thin, outspread, *Pulvinulina menardii*, the closely allied species *Pulvinulina canariensis*, *Pulvinulina crassa*, and *Pulvinulina micheliniana*, together with some minor varieties, constitute a complete gradational series, the shells of which, by successive modifications of the shape of the chambers and their setting-on, assume, to a greater or less degree, the biconvex, plano-convex, or subconical contour. The subordinate "specific" groups cannot be separated by any sharp lines of demarcation, but the central characters of each are well marked, and there is seldom any practical difficulty in assigning specimens to one or other of the recognised forms.

Pulvinulina menardii is more abundant than any of its congeners as a pelagic organism. It was taken in surface-gatherings, during the Challenger cruise, at nine points in the North Atlantic, at seven in the South Atlantic, at six in the South Pacific, and at seven in the North Pacific.

Its distribution, within certain latitudes, is world-wide. The record furnished by bottom-dredgings includes altogether not less than one hundred localities, scattered over the North and South Atlantic, the North and South Pacific, the Indian Ocean, the Southern Ocean, the Mediterranean, and the Red Sea; the depth ranging from shallow water down to 2750 fathoms, but being seldom less than 200 fathoms. Its northern limit, so far as at present known, is about lat. 55° 11′ N. in the North Atlantic; its southern boundary about lat. 51° 36′ S. in the South Atlantic. In somewhat higher latitudes, north and south, it is replaced by *Pulvinulina canariensis*.

As a fossil it has been identified as far back as the Chalk-marl of Kent (Jones and Parker); and the white Cretaceous limestones of Sicily (Ehrenberg). It occurs in the Eocene of the Bavarian Alps (Gümbel), in the Miocene and Pliocene of Southern Italy (Seguenza); in a Pliocene deposit in the Nicobar Islands (Schwager); and in a white limestone, probably of similar or still later geological age in the New Britain group (Brady).

Pulvinulina menardii, var. *fimbriata*, nov. (Pl. CIII. fig. 3, *a.b.*).

This is a subordinate modification, dependent on the exuberant growth of the shell. The normal subcarinate or limbate peripheral border of the spire is increased by the further deposit of shell-substance, so as to form a thick, serrate, or fringe-like keel. The test is seldom so large as that of the type.

Free-swimming specimens of the fimbriate variety have been obtained in company

with the normal form at one point in the North Atlantic and at one in the South Pacific. It occurs in bottom-dredgings from three Stations in the North Atlantic, from four in the South Atlantic, and from one in the South Pacific.

Pulvinulina tumida, H. B. Brady (Pl. CIII. figs. 4–6).

Pulvinulina menardii, var. *tumida*, Brady, 1877, Geol. Mag., Dec. II. vol. iv. p. 294.
„ „ „ Id. 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 80.

Pulvinulina tumida is probably only a variety of *Pulvinulina menardii*, but the test is stouter and altogether more solidly built. Its general contour is oblong, both the superior and inferior faces are highly convex, and the peripheral edge thick or rounded, and little if at all constricted at the sutures; on the inferior face the segments are more or less inflated and the umbilicus sunken; the longer diameter is about $\frac{1}{25}$th inch (1 mm.).

This form was taken in the tow-net on three occasions, twice in the North Atlantic and once in the South Atlantic.

Its presence has been determined in bottom-dredgings from seven Stations in the North Atlantic, 450 to 2750 fathoms; from nine in the South Atlantic, 420 to 2475 fathoms; from eleven in the South Pacific, 20 to 2600 fathoms; and from two in the North Pacific, 500 to 1850 fathoms. Of these the most northerly is Station 45, lat. 38° 34′ N., the most southerly Station 323, lat. 35° 39′ S.; but with a few exceptions the points referred to are all within the tropics.

A few specimens were found with other Foraminifera in a piece of white limestone from the New Britain group, the precise geological age of which has not been determined, but otherwise the species has not been recognised in the fossil condition.

Pulvinulina canariensis, d'Orbigny, sp. (Pl. CIII. figs. 8–10).

Rotalina canariensis, d'Orbigny, 1839, Foram. Canaries, p. 130, pl. i. figs. 34–36.
Pulvinulina repanda, var. *menardii*, subvar. *canariensis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 395, p. 16, figs. 47–49.
„ *canariensis*, Owen, 1876, Journ. Linn. Soc. Lond., vol. ix., Zool., p. 148, pl. v. fig. 21.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 80.
„ „ Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 207, pl. iii. figs. 59, 60.

Pulvinulina canariensis may be treated as a feeble modification of *Pulvinulina menardii*. The test is smaller than that of the type, the two lateral faces are nearly equally convex, and the periphery is acute or subcarinate; it has usually only four or five segments in the outer whorl, and they are so combined that the ends project considerably at the margin; there is but little sutural limbation, frequently none.

Pulvinulina canariensis inhabits a somewhat larger area than the typical *Pulvinulina menardii*, its northern and southern limits being lat. 60° 32′ N., and lat. 46° 40′ S. respectively. It is less common than the type in the tropics, and more generally diffused in the north and south temperate zones; hence in the "Porcupine" dredgings *Pulvinulina canariensis* is abundant, whilst well-characterised examples of *Pulvinulina menardii* are extremely rare.

Surface-specimens were obtained by the Challenger naturalists at three points in the North Atlantic, at ten in the South Pacific, and at one in the North Pacific. It has been observed in bottom-dredgings from fifty to sixty Challenger and "Porcupine" Stations, distributed over the North and South Atlantic, the Southern Ocean, and the South Pacific. It is much less common in the North Pacific and the Indian Ocean.

Mr. Robertson has specimens of *Pulvinulina canariensis* from the Post-tertiary beds of Garvel Park, Greenock; but with this exception the species has not been identified in the fossil condition.

Pulvinulina patagonica, d'Orbigny, sp. (Pl. CIII. fig. 7, *a.b.c.*).

Rotalina patagonica, d'Orbigny; 1839, Foram. Amér. Mérid.; p. 36, pl. ii. figs. 6–8.
Pulvinulina scitula, Brady, 1882, Proc. Roy. Soc. Edin., vol. xi. p. 716.

"A variety of *Pulvinulina canariensis*, differing from the typical form in its relatively small size and compact habit of growth. The margin is rounded instead of sharp, and the peripheral ends of the chambers are only slightly convex instead of standing out prominently as in *Pulvinulina canariensis*. Notwithstanding its minute dimensions, it generally attracts attention by its glistening white appearance. Longer diameter, $\frac{1}{100}$th inch (0·25 mm.)," or more.

This variety was noticed in the foregoing terms under the name *Pulvinulina scitula*, in the "Knight Errant" Report (*loc. cit.*) When that Report was written, I had overlooked or only partially considered d'Orbigny's previous description and figures of *Rotalina patagonica*, which, notwithstanding some discrepancies, I am now convinced are intended for the same form. The diameter of the test, according to d'Orbigny, is one-sixth of a millimètre ($\frac{1}{150}$th inch); his specimens, however, were from comparatively shallow water; those from the Faröe Channel were somewhat larger, about $\frac{1}{100}$th inch; but, on deep bottoms in the South Pacific and elsewhere, the test frequently measures $\frac{1}{40}$th inch in its longer diameter.

A few rather doubtful surface-specimens of *Pulvinulina patagonica* have been observed in one tow-net gathering in the South Atlantic, and in one from the west coast of Patagonia. It is, however, so common a constituent of bottom-dredgings and so widely diffused, that more evidence is required before it can be classed amongst normally pelagic organisms. The following is the record of its geographical distribution:—twenty-one Stations in the North Atlantic, depths from 90 to 2435 fathoms; eight in the South

Atlantic, 1025 to 2350 fathoms; one in the Southern Ocean, 1570 fathoms; seven in the South Pacific, 610 to 1940 fathoms; and four in the North Pacific, 500 to 2900 fathoms. These are scattered over an area stretching from lat. 60° N. in the North Atlantic, to lat. 46° S. in the Southern Ocean.

Pulvinulina crassa, d'Orbigny, sp. (Pl. CIII. figs. 11, 12).

Rotalina crassa, d'Orbigny, 1840, Mém. Soc. géol. France, vol. iv. p. 32, pl. iii. figs. 7, 8.
Pulvinulina crassa, Owen, 1867, Journ. Linn. Soc. Lond., vol. ix., Zool., p. 148, pl. v. figs. 8 (?), 9.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 80.

The morphological features of *Pulvinulina crassa* are intermediate between those of *Pulvinulina canariensis* and *Pulvinulina micheliniana*. The superior face of the test is nearly flat, the inferior highly convex and slightly excavated at the umbilicus; the segments are somewhat inflated, and the contour altogether less angular than in the latter species; the surface of the shell is often rugose on the inferior side. In the peripheral outline and segmentation of the superior face it resembles *Pulvinulina canariensis*, whilst the convexity of the inferior side approaches that of *Pulvinulina micheliniana*. It may be regarded as the isomorph of *Truncatulina lobatula*.

Surface-specimens of *Pulvinulina crassa* have been identified at one Challenger Station in the South Atlantic, and at eight in the South Pacific.

Its area of distribution, as determined from bottom-specimens, is scarcely so wide as that of either of its immediate allies, nevertheless it has been collected at ten Challenger and "Porcupine" Stations in the North Atlantic, depths 725 to 2740 fathoms, the most northerly being at lat. 54° 53′ N.; at seven in the South Atlantic, 420 to 2350 fathoms; at one in the North Pacific, 2250 fathoms; at fifteen in the South Pacific, 150 to 2335 fathoms; and at two in the Southern Ocean, 1375 and 1950 fathoms respectively, the most southerly being at lat. 53° 55′ S.

The fossil remains of the species are not uncommon in the Chalk of the neighbourhood of Paris and of some parts of Kent, but I find no mention of their occurrence in later formations.

Pulvinulina micheliniana, d'Orbigny, sp. (Pl. CIV. figs. 1, 2).

Rotalina truncatulinoides, d'Orbigny, 1839, Foram. Canaries, p. 132, pl. ii. figs. 25–27.
„ *micheliniana*, Id. 1840, Mém. Soc. géol. France, vol. iv. p. 31, pl. iii. figs. 1–3.
Discorbina micheliniana, Reuss, 1865, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lii. p. 455, No. 1.
Pulvinulina repanda, var. *menardii*, subvar. *micheliniana*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 396, pl. xiv. fig. 16; pl. xvi. figs. 41–43.
„ *micheliniana*, Owen, 1867, Journ. Linn. Soc. Lond., vol. ix., Zool., p. 148, pl. v. fig. 17.
„ „ Brady, 1879, Quart. Journ. Micr. Sci., vol. xix., N. S., p. 80.

There need not be the least hesitation in assigning the *Rotalina truncatulinoides* of the "Canaries," and the *Rotalina micheliniana* of the "Chalk of Paris," to the same species; and as the memoirs in which they are respectively described were published nearly simultaneously,[1] the question of actual precedence of nomenclature is not of much importance. Parker and Jones have preferred the name attached by d'Orbigny to the Cretaceous specimens, and later writers have followed their usage in this respect.

Pulvinulina micheliniana represents the extreme development in one direction of the "*menardii*" series; namely, that in which the superior or spiral face of the shell is flat and the inferior highly convex or subconical. It is the isomorph of *Truncatulina refulgens*, from which species it is for the most part readily distinguishable by the more or less excavated umbilicus, and the projecting apical margins of the later segments.

Except at a single locality, just north of the equator, *Pulvinulina micheliniana* was not taken at the surface of the North Atlantic during the Challenger cruise. It was collected, however, amongst other pelagic organisms at three points in the South Atlantic, at four in the South Pacific, and at one in the North Pacific.

The wide-spread geographical distribution of the species is evidenced by the following record of the occurrence of dredged bottom-specimens:—Arctic Seas—Baffin's Bay and Smith Sound, as far north as lat. 79° 26′ N.; North Atlantic—thirty-eight Challenger and "Porcupine" Stations, depths 90 to 2740 fathoms; South Atlantic—twelve Stations, 100 to 2475 fathoms; North Pacific—five Stations, 345 to 2950 fathoms; South Pacific—nineteen Stations, 15 to 2600 fathoms; Southern Ocean—four Stations, 50 to 1570 fathoms, as far south as lat. 46° 46′ S. It is plentiful also in the Mediterranean and the Indian Ocean.

As a fossil the species has been found in the Cretaceous formations of England (Ehrenberg, Jones and Parker), Ireland (Wright), France (d'Orbigny, Ehrenberg), Germany, Austria, and Bohemia (Reuss, Karrer), New Jersey (Ehrenberg), and elsewhere. It has likewise been obtained from the London Clay (Jones and Parker), and from the Pliocene and Post-tertiary formations of Southern Italy (Seguenza); but our knowledge of its occurrence in deposits of Tertiary age is manifestly incomplete.

Pulvinulina umbonata, Reuss (Pl. CV. fig. 2, *a.b.c.*).

Rotalina umbonata, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 75, pl. v. fig. 35, *a.–c.*

Pulvinulina umbonata, Id. 1866, Denkschr. d. k. Akad. Wiss. Wien, vol. xxv. p. 206.

„ „ Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, vol. iv. p. 77, pl. ix. fig. 8, *a.–c.*

[1] "Nous avons publié, l'année dernière, trois ouvrages spéciaux sur les Foraminifères: 1°. Un travail d'ensemble, descriptif et historique, et un *Genera* complet dans *l'Histoire naturelle de l'île de Cuba*, de M. de la Sagra, avec le Faune locale des Antilles (1 volume in -8°., avec 12 planches in -fol.); 2°. la Faune des îles Canaries, dans *l'Histoire naturelle des îles Canaries*, par MM. Webb et Berthelot; 3°. la Faune de la craie blanche de Paris, dans les *Mémoires de la Société géologique de France*." Foram. Amér. Mérid. (dated 1839), p. 1, footnote.

A deep-water variety, distinguished with difficulty from several allied and collateral forms. The test is small and neatly constructed; the superior face exhibits fully three convolutions, the segmentation of which is marked externally by nearly straight, radial, non-limbate sutures. It is isomorphous with *Truncatulina tenera*.

Pulvinulina umbonata is not a pelagic species. More or less characteristic specimens have been found in bottom-dredgings from five Stations in the North Atlantic, depth 435 to 2750 fathoms; from five in the South Atlantic, 675 to 2475 fathoms; from twelve in the South Pacific, 37 to 2350 fathoms; from three in the North Pacific, 345 to 3125 fathoms; and from one in the Southern Ocean, 1375 fathoms.

It occurs in the Septaria-clays and other formations of early and middle Tertiary age in various parts of Central and Southern Europe (Reuss, Hantken, Seguenza, &c.).

Pulvinulina exigua, n. sp. (Pl. CIII. figs. 13, 14).

Test free, Rotaliform; both faces convex, the inferior less so than the superior, periphery acute, lobulated; composed of three convolutions, of which the outermost has usually five segments. Sutures non-limbate; marked on the superior face by thickened lines of opaque-white shell-substance; on the inferior by slight depressions. Diameter, $\frac{1}{65}$th inch (0·4 mm.), or less.

This is a deep-water variety, nearly related to *Pulvinulina partschiana* and *Pulvinulina umbonata*, from which forms it may be distinguished by its comparatively minute size, the smaller number of segments in each whorl, and their inflated contour, and the lobulated outline of the test.

The record of its distribution is as follows:—twelve Stations in the North Atlantic, the depths ranging from 64 fathoms to 2740 fathoms; four in the South Atlantic, 1025 fathoms to 2475 fathoms; three in the Southern Ocean, 1300 fathoms to 2600 fathoms; ten in the South Pacific, 129 fathoms to 2350 fathoms; and five in the North Pacific, 15 fathoms to 2300 fathoms. Of the thirty-four Stations enumerated, twenty-five have depths exceeding 1000 fathoms and fourteen exceeding 2000 fathoms.

Pulvinulina pauperata, Parker and Jones (Pl. CIV. figs. 3–11).

> *Pulvinulina repanda*, var. *menardii*, subvar. *pauperata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 395, pl. xvi. figs. 50, 51.

This striking and interesting species is figured by Parker and Jones in their "North Atlantic" memoir (*loc. cit.*); but no descriptive characters are furnished, beyond the passing remark that "it presents a feeble, and, as it were, accidental condition, in which the thin film of sarcode surrounding the few feebly marked chambers has been calcified beyond their verge."

The test of *Pulvinulina pauperata* is planospiral; in its adult condition it is thin and complanate, and characterised primarily by its broad lamelliform peripheral wing. The segments are numerous, and form from one to two convolutions of an evolute spire, the entire series being visible on both faces of the shell, though more convex on the superior side. The primordial chamber is often conspicuously large, but subsequently the segments increase progressively in size; individually they are somewhat inflated. The aperture is situated on the inferior side of the final segment, close to the carina. The diameter of the test often exceeds $\frac{1}{10}$th inch (2·5 mm.). The drawings on Pl. CIV. sufficiently illustrate the salient features of the organism at its various stages of growth.

Pulvinulina pauperata is essentially a deep-water Foraminifer, and there is no reason to suppose that it is, under any circumstances, a pelagic species. It has been obtained altogether at about twelve localities in the North Atlantic, at depths of 390 to 2176 fathoms, its northern limit being apparently about lat. 56° N.; at four Stations in the South Atlantic, 675 to 2350 fathoms; at one in the North Pacific, 1850 fathoms; at ten in the South Pacific, 129 to 1825 fathoms; and at two in the Southern Ocean, 1300 and 1375 fathoms respectively; it occurs also in the Indian Ocean. Its southern limit is the Antarctic Ice-barrier. Some of the specimens from far south are of very fine dimensions.

The species is not known in the fossil condition.

Pulvinulina schreibersii, d'Orbigny, sp. (Pl. CXV. fig. 1, *a.b.c.*).

Rotalina schreibersii, d'Orbigny, 1846, For. Foss. Vien., p. 154, pl. viii. figs. 4–6.
„ *badensis*, Czjzek, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 144, pl. xiii. figs. 1–3.
Pulvinulina schreibersii, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 393.
Truncatulina schreibersii, Seguenza, 1879, Atti. R. Accad. dei Lincei, ser. 3, vol. vi. p. 164, 149, &c.

This species has been selected as the type of that section of the genus which is characterised by the stellate sutural limbation of the inferior umbilicus.

Pulvinulina schreibersii has been observed at seven Challenger Stations, six of which are amongst the islands of the South Pacific, namely:—off New Hebrides, 125 fathoms; off Ki Islands, 129 fathoms; south-west of Papua, 28 fathoms; off Raine Island, 155 fathoms; off Cape York, Torres Strait, 3 to 11 fathoms; Humboldt Bay, Papua, 37 fathoms; and off Admiralty Islands, 17 fathoms; the remaining locality being off Bermuda, 435 fathoms. Parker and Jones record its occurrence in the Red Sea, 40 fathoms, and in the Mediterranean, 90 fathoms.

Its geological history reaches back to about the middle of the Tertiary epoch. It occurs in the Miocene of various parts of Austria (d'Orbigny, Karrer) and of Southern Italy (Seguenza), and in the later Tertiaries of Italy and the south-east of Spain (Parker and Jones, Seguenza).

Pulvinulina procera, H. B. Brady (Pl. CV. fig. 7, *a.b.c.*).

Pulvinulina procera, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 66.

Test trochoid; forming an elevated cone with rounded apex and flat or truncate inferior face; composed of numerous convolutions, the last of which consists of about six segments; segmentation very oblique, indistinct on the superior face, especially near the centre; sutures and periphery more or less limbate on the inferior side; aperture an arched slit at the margin of the final segment, near the umbilicus. Diameter, $\frac{1}{22}$nd inch (1·1 mm.).

This species finds its nearest ally in *Pulvinulina schreibersii*, to which in many respects it bears a close resemblance; the tall conical outline of the test, however, is sufficiently distinctive.

Pulvinulina procera occurs in coral-sands dredged off Kandavu, Fiji Islands, 210 fathoms; and at two points in Torres Strait—off Raine Island, 155 fathoms, and off Cape York, 3 to 11 fathoms.

Pulvinulina karsteni, Reuss, sp. (Pl. CV. figs. 8, 9).

Rotalia karsteni, Reuss, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 273, pl. ix. fig. 6.
Pulvinulina karsteni, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 470, pl. xlviii. fig. 15.
„ *repanda*, var. *karsteni*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 396, pl. xiv. figs. 14, 15, 17; pl. xvi. figs. 38–40.

The test of *Pulvinulina karsteni*, in well-developed specimens, is nearly round and very regularly built, convex on both faces, and with obtuse subangular periphery. It is composed of from three to four convolutions, the final circuit having about seven chambers; the sutures, which are marked by fine lines on the superior face, are somewhat depressed on the inferior; and the margin of the test on the inferior side has a limbate border.

Pulvinulina karsteni is not a pelagic species. It is most at home and attains its best dimensions in the bottom-mud of the arctic seas, and is entirely wanting within the tropics. It was found in twenty-one out of the twenty-four samples of the sea-bottom, procured from depths of 13 to 220 fathoms, in Baffin's Bay and Smith Sound, on the last British North-Polar Expedition, the most northerly being at lat. 83° 19′ N.; and it was present in all the soundings, seventeen in number, taken on the shores of Novaya Zemlya and Franz-Josef Land, at depths of 70 to 145 fathoms, during the Austro-Hungarian Expedition. It has been dredged off Shetland, in Dublin Bay, and at two "Porcupine" Stations and one Challenger Station in the North Atlantic, the latter, in lat. 38° 34′ N., representing its southern limit in the northern hemisphere. In the southern hemisphere the species is less common, and the specimens as a rule of smaller size; nevertheless, characteristic examples have been obtained in Challenger material from

Magellans Strait, 55 fathoms; from two points on the west coast of Patagonia, 45 and 160 fathoms; from the Falkland Islands, 4 fathoms; and from the mouth of the Rio de la Plata, 13 fathoms; the last named being in lat. 35° 2′ S. Messrs. Parker and Jones, however, have obtained small specimens in the South Atlantic, as far north as lat. 26° 45′ S.

The geological distribution of the species commences with the Upper Cretaceous formations. It occurs in the Green-sand of New Jersey, and in the Chalk of Mecklenburg (Reuss); in the Pliocene and Post-pliocene beds of Southern Italy (Seguenza); and in the Sub-recent clays of Cambridgeshire and Lincolnshire (Parker and Jones).

Pulvinulina elegans, d'Orbigny, sp. (Pl. CV. figs. 4, 5, 6).

"Nautili *Ammoniformes* sive *trochiformes*," Soldani, 1780, Saggio Oritt., p. 99, pl. ii. fig. 13.
Rotalia (*Turbinulina*) *elegans*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 276, No. 54.
Pulvinulina elegans, Parker, Jones, and Brady, 1871, Ann. and Mag. Nat. Hist., ser. 4, vol. viii. p. 174, pl. xii. fig. 142.

Pulvinulina partschiana, d'Orbigny, sp. (Pl. CV. fig. 3, *a.b.c.*, woodcut, fig. 21).

Rotalina partschiana, d'Orbigny, 1846, For. Foss. Vien., p. 153, pl. vii. figs. 28–30; pl. viii. figs. 1–3.
,, ,, var., Bornemann, 1855, Zeitschr. d. deutsch. geol. Gesellsch., vol. vii. p. 340, pl. xvi. fig. 6, *a.–c.*
Rotalia elegans, Parker and Jones, 1860, Quart. Journ. Geol. Soc., vol. xvi. p. 455; pl. xx. fig. 46.
Pulvinulina repanda, var., *elegans*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 397 pl. xvi. figs. 44–46.
Rotalia flosculiformis, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 262, pl. vii. fig. 109.
Pulvinulina partschiana, Reuss, 1870, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lxii. p. 36;—Schlicht, 1870, Foram. Pietzpuhl, pl. xx. figs. 23–25, 29–31.
Pulvinulina elegans, Blake, 1876, Yorkshire Lias, p. 472, pl. xvii. figs. 38, 38*a*.
Placentula partschiana, Berthelin, 1882, Bull. Soc. géol. France, sér. 3, vol. xi. p. 16.

The *Rotalia elegans* of the "Tableau Méthodique," founded upon figures in Soldani's "Testaceographia," passes by insensible gradations into the *Rotalina partschiana* of the "Vienna Basin" memoir. The particular variety represented by the former figure attains larger dimensions, the test is less convex and therefore relatively thinner, and the septa are marked by broad clear lines, neither elevated nor depressed; whilst in the latter the sutures, especially on the inferior face, are generally more or less limbate externally. Well characterised specimens of the two forms are portrayed in Pl. CV. fig. 3 and figs. 4–6 respectively. At six Challenger Stations both varieties present themselves, and with them passage-forms of every intermediate contour. Morphologically the points of difference, even in extreme examples, are comparatively trifling, and they appear to be

dependent upon local conditions, of which depth of water is probably the most important. Setting aside the six Stations referred to, at which both forms occur, the average depth of nineteen recorded localities for *Pulvinulina elegans* is 340 fathoms; that of twenty-three Stations at which *Pulvinulina partschiana* has been noted, 1000 fathoms. Speaking in general terms, the home of the former is from the littoral zone to a depth of 600 or 700 fathoms, that of the latter from about 300 fathoms to 2000 fathoms; whilst passage-forms are commonest at 800 to 1300 fathoms.

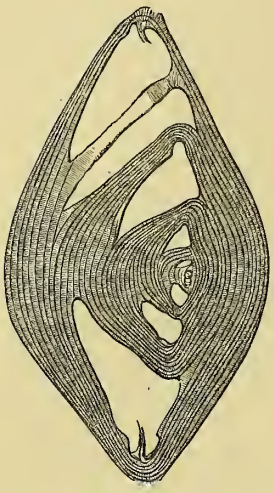

Fig. 21.—Transverse section of *Pulvinulina partschiana*, showing the thickness of the shell-wall and its Nummuline lamination. Magnified 40 diameters.

The differences in external appearance are chiefly due to the thickening of the shell wall. Deep-water specimens of *Pulvinulina partschiana* exhibit a mode of growth very similar to that of a Nummulite—the alar flaps of each new chamber spreading over the lateral surfaces, and giving rise to the lamination of the walls shown in the annexed drawing of the transverse section of the test. With increased age the test looses translucency and becomes opaque-white and dull externally.

The normal aperture of *Pulvinulina elegans* (and *partschiana*) is a fissure at the inferior margin of the final chamber, close to the line of union with the previous convolution. But this is not an invariable character, and specimens from certain localities exhibit a somewhat anomalous feature in the form of a supplementary orifice. This has the aspect of a long, arched, linear slit, immediately within the peripheral margin of the final segment on the inferior side, and parallel to it—that is to say, an opening between the carinal border and the proper wall of the terminal chamber. The peculiarity referred to was pointed out to me several years ago by my friend M. Schlumberger, and it has since formed the subject of a "Note" by M. Berthelin (*loc. cit.*) The specimens in which it occurs are identical in every other respect with the typical form, and in some cases at any rate still retain the normal aperture in addition. M. Berthelin, speaking chiefly from fossil specimens, has observed the coexistence of two apertures, but states that the orifice which occupies the ordinary position is of far less importance than that at the periphery. He also states, what is an evident fact, that the peripheral aperture is obliterated when a new chamber is formed; and this of itself appears sufficient evidence that the connection between the segments is maintained by stoloniferous orifices in the normal position. More recently M. Schlumberger has described living specimens possessing the same peculiarity under the name *Rotalina pleurostomata* (Feuille des Jeunes Naturalistes, ann. xiii. p. 27, pl. iii. fig. 5). The nearest analogy to the phenomenon in question is perhaps to be found in *Truncatulina rostrata;* and in this species, as already explained (p. 669), the peripheral or supplementary aperture has not been satisfactorily traced beyond a few of the later segments. Terquem has formed a quasi-generic group,

to which he has given the name *Epistomina*, consisting chiefly of Mesozoic *Pulvinulinæ* of the "*elegans*" type, of which the apertures are more or less abnormal as to form or position.[1]

Pulvinulina partschiana is common in the North Atlantic and South Pacific, less common in the South Atlantic and North Pacific; and it occurs also in the Mediterranean. The same may be said of *Pulvinulina elegans;* but that form affects warmer latitudes, and its area of distribution is correspondingly narrower.

With respect to their geological range, I am unable to separate the two forms. One or the other has been found in the Upper Trias of Derbyshire (Jones and Parker); in the Lower and Upper Lias of various parts of England (Blake, Walford, Brady); in the London Clay (Jones and Parker); in the Septaria-clays of many parts of Germany (Reuss, Bornemann); in numerous Miocene deposits of Central and Southern Europe (d'Orbigny, Reuss, Karrer, Seguenza, &c.), and in the later Tertiaries of Italy, Spain, and elsewhere (Seguenza, Jones and Parker, Schwager, &c.).

Pulvinulina berthelotiana, d'Orbigny, sp. (Pl. CVI. fig. 1, *a.b.c.*).

Rotalina berthelotiana, d'Orbigny, 1839, Foram. Canaries, p. 130, pl. i. figs. 31–33.
Pulvinulina berthelotiana, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 393.

A small, round, neatly-made shell, the superior face subconical, the inferior more or less convex, the sutures, both of the superior and inferior side, conspicuously limbate.

Found in sands dredged at two points near the coast of Papua, namely:—Station 189, south of the Island, 25 fathoms, and off the Admiralty Islands, on the north, 16 to 25 fathoms. D'Orbigny states that the species is rather common in the shore-sand of Teneriffe.

Pulvinulina favus, H. B. Brady (Pl. CIV. figs. 12–16).

Pulvinulina favus, Brady, 1877, Geol. Mag., Dec. II., vol. iv. p. 294.

Test lenticular, the two lateral faces nearly equally convex, periphery subangular or slightly rounded; composed of a large number of narrow segments arranged in about two convolutions; aperture an elongate or oval fissure, placed obliquely either on the peripheral edge or somewhat within it on the inferior side; the exterior surface of the test, except a small area surrounding the aperture, covered with a raised reticulated ornament, which entirely conceals the internal structure. Diameter, $\frac{1}{30}$th inch (0·84 mm.).

This is a somewhat remarkable species, the structural features of which are completely hidden by a thick exogenous deposit of shell-substance, forming a "honeycomb" ornament, not unlike that of *Lagena squamata* or *Lagena hexagona*, over almost the entire surface of the test. Young specimens are relatively much thicker than the adults, and have the

[1] Foram. du Syst. Oolith., 5ième Mém., 1883, p. 373.

margin blunt or rounded. The ornament likewise varies with age, being more distinctly linear and geometric in the early stage (fig. 15), thicker and less regular in old specimens (fig. 16).

So far as at present known, *Pulvinulina favus* is exclusively a Pacific species; indeed, but for a few specimens obtained at Station 224, about eight degrees north of the equator, it might be said to be peculiar to the South Pacific, inasmuch as the remaining nine Stations at which it has been found lie between the equator and lat. 42° 43′ S. It is a deep-water organism, with a bathymetrical range extending from 1375 fathoms to 2600 fathoms.

Rotalia, Lamarck.

Nautilus, pars, Linné [1767], Walker and Boys, Adams, Montagu, Maton and Rackett, Parkinson, Pennant, Dillwyn, Turton, &c.
Rotalia, Lamarck [1804], d'Orbigny, Fleming, Bronn, Michelotti, Hagenow, Macgillivray, Thorpe, Parker and Jones, Reuss, Carpenter, Sowerby, Brady, M. Sars, Schwager, Karrer, Schulze, &c.
Discorbula, Lamarck [1816].
Streblus, Fischer [1819].
Gyroidina, d'Orbigny [1826], Bronn.
Turbinulina, pars, d'Orbigny [1826].
Calcarina, pars, d'Orbigny [1826], Carpenter, Parker and Jones, Brady.
Rotalites, Defrance [1827].
Asterigerina, pars, d'Orbigny [1839].
Rotalina, pars, d'Orbigny [1839], Reuss, Czjzek, Bornemann, Williamson, Karrer, Seguenza, Alcock, Hantken, Parfitt, Schlicht, Stewart, Terquem, Norman, Martonfi, &c.
Rosalina, pars, d'Orbigny [1839], Reuss, Costa, Egger, Karrer, Schlicht.
Discorbis, Macgillivray [1843].
Faujasina, Williamson [1853].

As compared with the collateral genera, *Planorbulina* and *Pulvinulina*, the true *Rotaliæ* form but a small series; and the range of morphological variation which they exhibit, so far as the more conspicuous features of the test are concerned, is embraced within much narrower limits.

The general conformation of the shell is that of a turbinoid spire, which in its typical phase (*Rotalia beccarii*) is nearly equally convex on the two faces. Some varieties, however, present a convex, or even conical, superior face, whilst the inferior side is flat (*Rotalia nitida*); and on the other hand, there is a more important set of forms, in which the superior face is approximately flat and the inferior highly convex (*Rotalia soldanii*, *Rotalia schroeteriana*, &c.)—between the two extremes every gradation of contour is exemplified in the series.

The normal "Rotaliform" arrangement of the chambers, by which the whole of the segments are visible on the superior side of the test, those of the final convolution only on the inferior, is tolerably constant throughout the genus, the only marked

exception being *Rotalia ammoniformis*, an outspread modification of the type in which the later whorls are somewhat evolute, that is to say, so far non-embracing as to leave a portion of the earlier convolutions visible on the inferior side.

The umbilicus is sometimes depressed or deeply excavated, but more frequently it is filled with a deposit of clear shell-substance. The aperture of the test, typically, resembles that of the other Rotaline genera—a simple curved chink or fissure on the inferior face of the terminal segment, close to the line of union with the previous convolution, and is usually placed nearer the peripheral than the umbilical margin. The exterior of the test is either entirely smooth (*Rotalia soldanii*), or smooth above and granular beneath (*Rotalia beccarii*); or the sutures are marked externally by raised bands or rows of exogenous beads (*Rotalia ornata*); or, lastly, in rare instances the surface of the shell is ornamented with a network of embossed lines (*Rotalia clathrata*).

The most striking deviation from the normal Rotaline contour occurs in certain species, the tests of which have calcarate or rowelled margins. This condition is produced in two different ways,—either the peripheral ends of the chambers are drawn out so as to form points or projecting angles (*Rotalia calcar*); or else three or four long spines are thrown out by the septa of the first whorl of chambers, and diverge radially from the periphery of the test (*Rotalia pulchella*).

A somewhat anomalous modification of the typical structure, resembling the "Asterigerine" varieties of *Discorbina*, presents itself in *Rotalia carinata* and *Rotalia lobata*,[1] two forms in which "the umbilical lobes of the chambers are separated from the principals by the intervention of a septum, so as to constitute a secondary series of chamberlets, which interdigitate or dovetail themselves between the proper chambers, as do those of the lower surface of *Amphistegina vulgaris* and its varieties, instead of lying in a lower plain like the subsidiary chambers formed by astral flaps in *Discorbina*."[2]

The microscopic structure of the test of *Rotalia* exhibits a marked advance on that of the allied genera. The walls are of fine texture, and the pores are as minute as those of the average of the NUMMULINIDÆ. In many, perhaps in the majority of species, the septa are double; and in some cases a considerable portion of the shell consists of an intermediate or supplemental skeleton, furnished with a more or less complicated canal-system,—a feature best illustrated by *Rotalia schroeteriana*.

The distribution of the genus may be very briefly indicated. No true *Rotaliæ* have been found within the Arctic or the Antarctic circle, but the genus is represented by one or other of its species in every part of the tropical and temperate zones. It attains its highest structural development, and the individual specimens their largest dimensions, in the shallow water of warm seas. It inhabits brackish pools and estuaries, is abundant in

[1] *Asterigerina carinata*, d'Orbigny, Foram. Cuba, p. 118, pl. v. fig. 25; pl. vi. figs. 1, 2; and *Asterigerina lobata*, ibid., p. 119, pl. v. figs. 19–21.

[2] Carpenter, Introd. Foram., p. 213.

littoral sands, and may be met with at every depth down to nearly 3000 fathoms. The first appearance of the genus geologically is in the Gault of Kent; it becomes comparatively common in the White Chalk, and increases in frequency at the successive stages of the Tertiary era.

Rotalia beccarii, Linné, sp. (Pl. CVII. figs. 2, 3).

"Cornu Hammonis," Plancus, 1739, Conch. Min., p. 8, pl. i. fig. 1, *A.B.C.*
"Ammonia unita," Gaultieri, 1742, Index Test., pl. xix. figs. *H.I.*
Nautilus beccarii, Linné, 1767, Syst. Nat., 12th ed., p. 1162;—1788, Ibid., 13th (Gmelin's) ed., p. 3370, No. 4.
"Hammoniæ conico-tuberculatæ," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 56, pl. xxxv. fig. *P.*
"Hammoniæ globoso-rotundatæ," Id. 1798, Ibid., vol. ii., App., p. 139, pl. ii. figs. *f. F.G.*
Discorbula ariminensis, Lamarck, 1816, Tabl. Encycl. et Méth., pl. cccclxvi. fig. 6, *a.b.*
Streblus beccarii, Fischer, 1819, Adversaria Zoologica, fasc. ii. p. 75.
Rotalia (*Turbinulina*) *beccarii*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 275, No. 42;—Modèle, No. 74.
„ „ *corallinarum*, Id. Ibid. p. 275, No. 48;—Modèle, No. 75.
„ „ *tortuosa*, Id. Ibid. p. 275, No. 40.
Rotalites discorbula, Defrance, 1827, Dict. Sci. Nat., vol. xlvi. p. 303.
Rosalina parkinsoniana, d'Orbigny, 1839, Foram. Cuba, p. 105, pl. iv. figs. 25–27.
„ *catesbyana*, Id. Ibid. p. 105, pl. iv. figs. 22–24.
„ *viennensis*, Id. 1846, For. Foss. Vien., p. 177, pl. x. figs. 22–24.
„ *amaliæ*, Costa, 1856, Atti dell' Accad. Pont., vol. vii. p. 254, pl. xxi. fig. 12, *A.–C.*
„ *radiata*, Id. Ibid. p. 255, pl. xxi. fig. 13, *A.–C.*
Rotalina beccarii, Williamson, 1858, Rec. For. Gt. Br., p. 48, pl. iv. figs. 90–92.
Rosalina mackeyi, Karrer, 1864, Novara-Exped., geol. Theil, vol. i. pt. 2, p. 82, pl. xvi. fig. 14.
Rotalia beccarii, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 388, pl. xvi. figs. 29, 30.
Rosalina maremii, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i. p. 27, pl. vii. fig. 15.
„ *trocheata*, Id Ibid. p. 28, pl. vii. fig. 18.
Rotalia punctato-granulosa, Seguenza, 1879, Atti dell' R. Accad. dei Lincei, ser. 3, vol. vi. p. 147, pl. xiii. fig. 37.
Rotalia beccarii, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 208, pl. iii. fig. 62; pl. iv. figs. 63–66.

Rotalia beccarii, the central species of the genus from a morphological point of view, and by far the best known, is not well represented in the Challenger collections.

In its typical presentment the test forms a depressed turbinoid spire, the two faces of which are nearly equally convex, and the peripheral edge rounded and more or less lobulated. The segments, which are numerous and a little inflated, are arranged in three to four convolutions; on the superior face the sutures are flush or very slightly depressed, and marked by the broad lines of the thick clear septa within; whilst on the inferior they are irregularly excavated, and their borders, as well as the umbilical portion of the surface, are studded with irregular exogenous granules. The septa of well-

developed typical shells are double. The specimens from which figs. 2 and 3 have been drawn are somewhat thicker and more compactly built than those commonly met with in northern seas, but in other respects they illustrate fairly the characters of the species.

Under the name *Rotalina nitida* (Rec. For. Gt. Br., p. 54, pl. iv. figs. 106–108), Prof. Williamson has described a starved modification of the type, frequent in some localities. The test is of small dimensions and of patelloid or subconical outline. Its walls are extremely thin and the septa are single.

The fine discoidal variety, named by d'Orbigny *Rotalia* (*Turbinulina*) *ammoniformis* (Ann. Sci. Nat., vol. vii. p. 276, No. 55;—Soldani, Testaceographia, vol. i. p. 55, pl. xxxiv. fig. *K*), common amongst the shore-sands of the Adriatic, and as a fossil in some of the later Tertiaries of Central Italy, differs from the typical *Rotalia beccarii* in the more complanate form of the shell, its very numerous segments, the absence of superficial granulation, and the somewhat evolute disposition of the later convolutions. It derives a certain interest from the fact that in respect of septation the test presents intermediate characters, some of the septa being single, whilst others of the same shell are distinctly double.

Rotalia beccarii is essentially a shallow-water species, most abundant in the littoral and laminarian zones of temperate seas. It inhabits the margins of all the great oceans, except the Arctic and the Antarctic, as well as those of the Mediterranean, the Adriatic, and the Red Sea. The farthest point north at which I find any note of its occurrence is about lat. 60° N., in the Shetland Seas; and its most southerly locality, off the Cape of Good Hope, lat. 35° S. The record of its distribution leaves no doubt that its home, whatever the latitude, is at depths of less than 50 fathoms; at the same time small specimens are known to occur sporadically in much deeper water, and such examples have been found at four Challenger Stations, of which the depths range from 1350 to 2950 fathoms.

Its earliest appearance as a fossil is about the middle of the Tertiary epoch. It has been obtained from the Miocene formations of Austria (Reuss, Karrer), and of Calabria (Seguenza); from the later Tertiaries of Central and Southern Italy, Spain, the Island of Rhodes, Bulgaria, New Zealand, &c. (Costa, Seguenza, Terquem, Jones and Parker, &c.); from the Crag of the eastern counties of England (Jones, Parker, and Brady); and from the Post-tertiary deposits of England, Scotland, Ireland, Norway, and Italy (Sars, Crosskey and Robertson, Wright, &c.).

Rotalia broeckhiana, Karrer (Pl. CVII. fig. 4, *a.b.c.*).

Rotalia broeckhiana, Karrer, 1878, Drasche's Geol. d. Insel Luzon, p. 98, pl. v. fig. 26.

A small thick variety of *Rotalia beccarii*, with somewhat tall spire and convex inferior face.

A few specimens with these characters not quite so strongly marked as indicated by Karrer's figure, were dredged off Ki Islands, 580 fathoms.

Rotalia orbicularis, d'Orbigny (Pl. CVII. fig. 5 ; Pl. CXV. fig 6).

Rotalia (*Gyroidina*) *orbicularis*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 278, No. 1 ;—Modèle, No. 13.

Rotalia orbicularis, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 470, pl. xlviii. fig. 16.

,, *beccarii*, var. *orbicularis*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 389, pl. xvi. fig. 34.

Rotalia orbicularis, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III., p. 60, pl. iv. figs. 1–3.

The test of *Rotalia orbicularis* is approximately plano-convex, the superior face being flat or only slightly arched, the inferior convex and more or less excavated at the umbilicus, and the peripheral edge subangular. It is isomorphous with *Truncatulina lobatula* in the Planorbuline series, and forms a connecting link between *Rotalia beccarii* and *Rotalia soldanii*.

The species is very widely diffused. It has been found over considerable areas of the North and South Atlantic, the Mediterranean, the Red Sea, the Southern Ocean, and the North and South Pacific, the record extending in all to nearly forty localities. Its northern limit appears to be about lat. 60° N., in the Atlantic ; its southern boundary about lat. 43° S., in the Southern Ocean. Its bathymetrical range extends from 100 fathoms to 2400 fathoms, but it is most at home at moderate depths.

Fossil specimens have been found in the London Clay (Jones and Parker) and in the Eocene formations near Paris (d'Orbigny, Terquem) ; in the Miocene of Southern Italy (Seguenza), and in the later Tertiaries of Italy and of the south-east of Spain (Jones and Parker) ; in the Crag of Antwerp (Reuss), and of Suffolk (Jones, Parker, and Brady), and in the Post-tertiary deposits of Norway (Crosskey and Robertson).

Rotalia soldanii, d'Orbigny (Pl. CVII. figs. 6, 7).

Rotalia (*Gyroidina*) *soldanii*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 278, No. 5 ;—Modèle, No. 36.

Rotalia girardana, Reuss, 1851, Zeitschr. d. deutsch. geol. Gesellsch., vol. iii. p. 73, pl. iii. fig. 34.

,, *beccarii*, var. *soldanii*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 389, pl. xvi. figs. 31–33.

,, *nitidula*, Schwager, 1866, Novara-Exped., geol. Theil, vol. ii. p. 263, pl. vii. fig. 110.

,, *soldanii*, Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt., p. 80, pl. ix. fig. 7, *a.b.c.*

The plano-convex habit of growth reaches its extreme development, so far as the present genus is concerned, in *Rotalia soldanii*, the test of which resembles that of *Rotalia orbicularis*, except that the convexity of the inferior or umbilical side is

considerably greater. The species corresponds morphologically to *Truncatulina refulgens* and *Pulvinulina micheliniana;* but the shell is more neatly and compactly built, the outlines more rounded, and the walls more finely perforated, than in either of the latter species. Sections of the test show that the septal walls are double, and that there is considerable deposit of shell-substance in the region of the umbilicus, but without any trace of canals.

Rotalia soldanii has a far wider geographical distribution than any other recent member of the genus. It is common in the North and South Atlantic, the Mediterranean, the Southern Ocean, and the North and South Pacific, its area extending at least from lat. 60° 14′ N., in the Atlantic, to the Antarctic Ice-barrier, lat. 64° 18′ S., in the Southern Ocean. Its home is on the bottom-ooze of the deep sea. Out of sixty localities at which its presence has been ascertained, only six have a depth of less than 300 fathoms, whilst thirty-nine are above 1000 fathoms, and twelve above 2000 fathoms.

Its geological range is also more extensive than that of its immediate allies. It has been observed in the Oligocene Septaria-clays of various districts of Germany (Reuss, Bornemann), and in the *Clavulina-szabói* beds of Hungary (Hantken); in the Miocene of several parts of Austria (d'Orbigny, Karrer), of Calabria (Seguenza), and of Malta (Brady); in the Salzthon of Wieliczka, in Galicia (Reuss); and in the later Tertiaries of Italy (d'Orbigny, Costa, &c.). If Dr. Carpenter's view be correct, that "the *Rotalina soldanii* of the Vienna Tertiaries is identical with the *Rotalina umbilicata* of the Chalk," and it is difficult to recognise any valid ground for separating them, the genealogy of the species reaches back to an even earlier geological period than has been indicated.

Rotalia schroeteriana, Parker and Jones (Pl. CXV. fig. 7, *a.b.c.*).

Faujasina, sp., Williamson, 1853, Trans. Micr. Soc. Lond., ser. 2, vol. i. p. 87, pl. x.
Rotalia schroeteriana (Parker and Jones, MS.), Carpenter, 1862, Introd. Foram., p. 213, pl. xiii. figs. 7-9.
„ *tuberosa*, Karrer, 1867, Sitzungsb. d. k. Ak. Wiss. Wien, vol. lv. p. 349, pl. i. fig. 4.

The test of *Rotalia schroeteriana*, in its typical condition, takes the form of a truncated cone, of which the broad, nearly flat, basal end represents the superior or spiral face. It attains comparatively large dimensions, often measuring $\frac{1}{12}$th inch (2 mm.) in diameter. It also displays a higher development of the supplemental skeleton and canal system than any of its congeners. The minute structure of the shell has been amply described and illustrated by Williamson (*loc. cit.*), and more recently by Dr. Carpenter.

No well-marked specimens of *Rotalia schroeteriana* have been met with in the Challenger dredgings. Though somewhat local in distribution, it is by no means rare amongst the islands of the Eastern Archipelago, at depths of less than 50 or 60 fathoms.

The *Rotalia tuberosa* of Karrer, which appears to be identical with the present species, was obtained from the Miocene formations of Lower Austria.

Rotalia papillosa, n. sp. (Pl. CVI. fig. 9, *a.b.c.*).

Test subglobular, slightly compressed; both faces highly convex, periphery obtuse and rounded; composed of three or four convolutions, the last of which has twelve to fourteen segments. Sutures limbate; marked externally either by interrupted raised lines, or more frequently by single or double rows of exogenous beads. Umbilical hollow filled with clear shell-substance, the exterior of which is granulated or irregularly fissured. Aperture an arched cleft at the inner margin of the inferior face of the final segment, near the periphery. Diameter, $\frac{1}{20}$th inch (1·27 mm.).

A thick, rounded modification, closely allied to *Rotalia schroeteriana*, but of inferior development, both in respect of size and minute structure.

It was obtained at seven Challenger Stations in the South Pacific and at one in the North Pacific, as follows:—Port Jackson, Australia, 2 to 10 fathoms; Torres Strait, 3 to 11 fathoms; two points amongst the islands south of Papua, 25 to 29 fathoms; Humboldt Bay, Papua, 17 fathoms; Nares Harbour, Admiralty Islands, 37 fathoms; off Amboyna, 15 to 20 fathoms; and Hong Kong Harbour, 7 fathoms.

Rotalia papillosa, var. *compressiuscula*, nov. (Pl. CVII. fig. 1, *a.b.c.*; young, Pl. CVIII. fig. 1, *a.b.c.*).

General characters similar to those of *Rotalia papillosa*, but the test much more compressed and the periphery sharply angular. Diameter, $\frac{1}{25}$th inch (1 mm.).

This variety is rather smaller than the more typical form, and the contour of the test is lenticular instead of nearly globular; the segmentation also and the disposition of the surface-ornament are generally more distinct and regular.

Rotalia papillosa, var. *compressiuscula* has been observed in dredged sands from eight Pacific Stations, namely:—Port Jackson, Sydney, 6 fathoms; three points on the southern coast of Papua, 25 to 29 fathoms; Humboldt Bay, Papua, 17 fathoms; off Amboyna, 15 to 20 fathoms; off the Philippines, 95 fathoms; and the Inland Sea, Japan, 14 fathoms. At five of these localities it occurs in company with the typical *Rotalia papillosa*.

Rotalia venusta, n. sp. (Pl. CVIII. fig. 2, *a.b.c.*).

Test compressed, sublenticular; superior face only slightly convex, often nearly flat, inferior convex; margin obtuse or rounded, more or less constricted at the sutures; composed of two convolutions or rather more, of which the later has about eight segments;

sutures somewhat limbate on the superior face, deeply excavated on the inferior; surface of the inferior side granular or rugose; aperture an elongated fissure at the inner side of the final segment, often placed at an angle to the margin of the previous convolution. Diameter, $\frac{1}{34}$th inch (0·75 mm.).

A somewhat variable form, nearly related to the compressed varicty of *Rotalia papillosa*, from which it is most readily distinguished by its fewer segments, and by the sunken sutures and granulated surface of the inferior side of the test.

The Challenger specimens are from five South Pacific Stations, four of which are amongst the islands south of Papua, depth 3 to 11 fathoms; the other, off Middle Island, west coast of Patagonia, 345 fathoms. But the finest examples that have been met with are from material dredged by my friend Mr. A. Haly, off Calpentyn, Ceylon, at a depth of 2 fathoms or thereabouts.

Rotalia clathrata, n. sp. (Pl. CVII. figs. 8, 9).

Test biconvex, periphery angular, subacute; composed of three convolutions; segments numerous, narrow, somewhat curved; aperture the normal arched fissure at the inner margin of the final segment; exterior of both faces of the test ornamented with a raised reticulation, consisting typically of the limbate sutures and transverse connecting bands, but sometimes less regularly constructed. Diameter, $\frac{1}{45}$th to $\frac{1}{30}$th inch (0·56 to 0·84 mm.).

This handsome species, with its very characteristic surface-ornament, has only been met with in the South Pacific. It occurs at four Stations between Australia and New Zealand, or more accurately, between East Moncœur Island, Bass Strait, and Cook Strait, the depth ranging from shallow water in Wellington Harbour to 275 fathoms. It has been found also at two Stations on the west coast of Patagonia, 160 fathoms and 175 fathoms respectively. The specimens obtained from the former area (fig. 8) are of larger dimensions, and the reticulation is strongly marked; those from the latter (fig. 9) are relatively small, and the sutural limbation of the inferior side less distinct.

Rotalia calcar, d'Orbigny, sp. (Pl. CVIII. fig. 3; and fig. 4 ?).

Calcarina calcar, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 276, No. 1;—Modèle, No. 34.
Rotalia armata, Id. Ibid. p. 273, No. 22;—Modèle, No. 70.
Calcarina calcar, Id. 1839, Foram. Cuba, p. 93, pl. v. figs. 22–24.
„ „ Carpenter, 1862, Introd. Foram., p. 223, pl. xiii. fig. 21.
„ *spengleri*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 24, pl. iii. fig. 87.
„ *armata*, Id. Ibid. p. 36, pl. iii. fig. 88.
Rotalina armata, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III., p. 67, pl. v. figs. 14, 15.

The distinction between the genera *Rotalia* and *Calcarina* is founded by Carpenter upon the porous or divided aperture, and the "extraordinary development of the supplemental skeleton" of the latter genus. If this view be accepted, and it appears to afford the only practicable basis of separation, the group of forms of which the present species may be taken as the type find their proper position in the genus *Rotalia*. The most familiar examples of the group referred to are *Calcarina calcar*, d'Orbigny, *Calcarina pulchella*, d'Orbigny, *Rotalia armata*, d'Orbigny, *Rotalia bisaculeata*, d'Orbigny, and *Rotalia dentata*, P. and J.; whilst *Calcarina defrancii*, d'Orbigny,[1] furnishes an intermediate link connecting them on the other hand with the true *Calcarinæ*. Excepting *Calcarina pulchella*, which has marginal spines originating in the earlier whorls, they are all characterised to a greater or less degree by the angular or pointed peripheral ends of the chambers; and the test presents either a dentate or a zig-zag outline, according to the size and shape of the projecting angles.

The drawing (Pl. CVIII. fig. 3) represents a well-marked typical specimen of *Rotalia calcar;* the smaller shell (fig. 4) is a young example, either of the same species or of the closely-allied *Rotalia dentata*, Parker and Jones.[2] Between d'Orbigny's models of *Calcarina calcar* and *Rotalia armata* I can detect no distinctive character of the least value.

Rotalia calcar is not uncommon in the shallow water coral-sands of the East and West Indies; it occurs also in the Mediterranean and the Red Sea; on the shores of Madagascar, the Mauritius, and Ceylon, and at the Cape of Good Hope.

Of its geological distribution I am unable to say more than that I have specimens from the Barton Beds (Eocene) of the Isle of Wight, and from the Miocene of Malta; and that Terquem figures what is apparently the same species from the Eocene of the neighbourhood of Paris.

Rotalia pulchella, d'Orbigny, sp. (Pl. CXV. fig. 8, *a.b.*).

Calcarina pulchella, d'Orbigny, 1839, Foram. Cuba, p. 92, pl. v. figs. 16–18.
Rotalia pulchella, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 387.

This beautiful little species appears to belong to the Rotalian rather than the Calcarine group. D'Orbigny's figures represent a clear, thin-walled Rotaliform shell, the segmentation of which is quite distinct on both faces, and the aperture a somewhat large, undivided, arched fissure. But its most remarkable feature consists of three long slender spines, which have their origin in the septal bands of the earlier convolutions, and form nearly equidistant peripheral radii. The spines are solid, and smooth externally,

[1] Moebius figures, under the name *Rotalia defrancei* (Foram. von Mauritius, pl. xiv.), a variety which I should prefer to call *Rotalia calcar;* but his general conclusions as to the Rotalian affinity of the forms under consideration are the same as my own.

[2] *Phil. Trans.*, vol. clv. p. 387, pl. xix. fig. 13, 1865.

that is to say, not marked with longitudinal furrows; they are either curved or straight, and are pointed at their extremities. The septa are double, and in large specimens the sutures are marked externally either by limbate lines or by rows of exogenous beads. The body of the test seldom measures more than $\frac{1}{50}$th inch (0·5 mm.) in diameter.

The present species must not be confounded with the *Rotalia pulchella* of d'Orbigny (Ann. Sci. Nat., vol. vii. p. 274, No. 32;—Modèle, No. 71), which, according to modern nomenclature, belongs to the genus *Pulvinulina*.

The Challenger collections furnish doubtful specimens of *Rotalia pulchella* from Kandavu, 255 fathoms; and Humboldt Bay, Papua, 37 fathoms. Better examples have been obtained from the Strait of Banca, 7 or 8 fathoms (Parker); off Java (Robertson); and off Penang (Siddall). The originally published habitat was the coast of Cuba.

Calcarina, d'Orbigny.

Nautilus, pars, Gmelin [1788], Fichtel and Moll, Dillwyn.
Siderolites, Lamarck [1801], Montfort, Blainville.
Siderolina, Blainville [1825], d'Orbigny (?).
Calcarina, d'Orbigny [1826], Bronn, Reuss, Carpenter, Parker and Jones, Morris and Quekett, Schwager, Gümbel, Brady, Carter, &c.

The structural relations of the genus *Calcarina* have been worked out with much care by Dr. Carpenter; and his account of the minute anatomy of the testaceous skeleton, first published in the Philosophical Transactions for 1860 (p. 548), and subsequently in the Introduction to the Study of the Foraminifera (p. 216), leaves no point of importance unnoticed.

In general terms, the typical form of the test of *Calcarina* is that of an irregular biconvex disk with radiating peripheral spines. These characters it shares to a greater or less extent with *Tinoporus* and with certain varieties of *Rotalia*. From *Tinoporus* the difference is primarily one of internal structure; but the two types are also distinguishable by external features, the later chambers of the Rotaliform spire of *Calcarina*, for example, being apparent on the inferior side of the disk, whilst in *Tinoporus* no portion of the spire is visible.

The affinity of *Calcarina* with *Rotalia* is of a much closer description, indeed it has been said with perfect justice that the characters which differentiate the two genera are altogether gradational. The most serviceable distinctions are,—firstly, the aperture, which in the typical *Calcarina* consists of a row of pores along the inner margin of the septal face; and secondly, the extraordinary development of the supplemental skeleton and the canal system. It is true that analogous structures are occasionally met with amongst the higher *Rotaliæ*, but they differ from those of *Calcarina* both in nature and extent, and the exceptional specimens in which they form a conspicuous feature are not such as resemble the latter genus in external contour.

If this view as to the essential characters of the genus *Calcarina* be accepted, it becomes obvious, as already suggested, that such forms as the *Calcarina calcar* and *Calcarina pulchella* of d'Orbigny must be transferred to the true *Rotaliæ*, notwithstanding the ray-like peripheral extensions of the test; inasmuch as they have the simple slit-like aperture and the comparative absence of supplemental skeleton which characterises the latter genus.

In the living condition *Calcarina* is common in the seas of tropical latitudes, though somewhat local in its distribution; it is less common in the warmer regions of the temperate zone, and is not found further north than the Mediterranean and the Adriatic. It attains its best development at depths of less than 100 fathoms. As a fossil its earliest appearance is probably in the Chalk of the south-east of England (Jones); it is abundant in the Chalk of Maestricht, and the specimens are of fine dimensions. It occurs in the Eocene of the Paris Basin, in the Miocene both of Europe and America, and probably also in the later deposits.

Calcarina spengleri, Linné, sp. (Pl. CVIII. figs. 5, 7).

"Ammonshorn," Spengler, 1781, Danske Skriften, vol. i. p. 379, pl. ii. fig. 9, *a.b.c.*
Nautilus spengleri, Linné, 1788, Syst. Nat., 13th (Gmelin's) ed., p. 3371, No. 10.
Siderolites calcitrapoides, Lamarck, 1801, Syst. des Anim. s. Vert., p. 376;—1816, Tableau Encycl. et Méth., pl. cccclxx. fig. 4, *a.–k.*
Nautilus spengleri, Fichtel and Moll, 1803, Test. Micr., p. 84, pls. xiv. xv. (in part).
Calcarina spengleri, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 276, No. 4.
„ „ Carpenter, 1860, Phil. Trans., p. 548, pls. xix., xx.;—1862, Introd. Foram., p. 216, pl. xiv.
„ *calcitrapoides*, Reuss, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 315, pl. iv. figs. 1–4, 6.

The *Nautilus spengleri* of Linné and Gmelin is based upon drawings accompanying a paper by Lorentz Spengler in the first volume of the "Danish Transactions." Spengler's specimens were brought from Amboyna, and his figures represent somewhat roughly, but unmistakably, the large well-marked variety which embodies the typical characters of the genus *Calcarina*. Similar but less regular forms were subsequently figured by Schroeter,[1] from specimens procured from the Adriatic; and the type was further illustrated by Fichtel and Moll a few years later. In modern times, the external characters of the organism and its internal structure have been minutely described by Dr. Carpenter.

Typically the test of *Calcarina spengleri* takes the form of a lenticular disk with radiating marginal spines; the two sides are nearly equally convex, and the surface is generally studded with slightly raised tubercles of solid semi-transparent shell-substance. The spines, which vary greatly in number, are generally straight and cylindrical, and either

[1] Neue Litteratur und Beiträge zur Kenntniss der Naturgeschichte, sonderlich der Conchylien und der Steine, 1784, p. 307, figs. 3–6.

taper a little towards the extremity, or are club-shaped, with the broad end outwards; occasionally they assume less regular forms and become variously branched and subdivided. They generally spring from near the peripheral edge of the test, but this is by no means a constant rule, and specimens are met with in which they radiate from almost every portion of the surface.

The exterior of the test yields but little information as to its internal structure. Sections, however, show that it is composed of three or four convolutions of an inequilateral spire, each circuit consisting of a relatively large number of chambers. The convolutions are non-embracing, and the spire is arranged in the form of a depressed cone. Except a portion of the final convolution, the whole is encased in a thick deposit of shell-substance, which not only fills the umbilical hollow and forms a convex layer on both faces, but produces also the marginal spines. This deposit, which is in fact the "supplemental skeleton," is traversed by a complicated system of ramifying canals, the open ends of which are seen externally in the form of large superficial pores. The aperture consists of a row of small rounded orifices along the inner margin of the final segment.

The Challenger collections add but little to our knowledge of the distribution of the species. It occurs in material dredged at eight Stations in various parts of the East Indian Archipelago. One of these, off Amboyna, has a depth of 1425 fathoms; the others range from 6 to 155 fathoms, and represent more nearly its normal habitat.

D'Orbigny, Parker and Jones, and Carpenter all agree that *Calcarina spengleri* is identical with the *Siderolites calcitrapoides* of Lamarck, so that its earliest appearance, geologically speaking, must be placed at least as far back as the Chalk of Maestricht. It occurs in the Eocene and Miocene of several parts of Europe; but owing to the confusion of nomenclature it is difficult to distinguish this from many of the allied species enumerated in the published fauna-lists of the Tertiary formations.

Calcarina hispida, H. B. Brady (Pl. CVIII. figs. 8, 9).

Calcarina hispida, Brady, 1876, Proc. R. Irish Acad., ser. 2, vol. ii. p. 590.
,, *calcar*, var. *hispida*, Carter, 1880, Ann. and Mag. Nat. Hist., ser. 5, vol. v. p. 453.

The present variety displays the same general structure as *Calcarina spengleri*, but the test is seldom quite so large. The entire surface is hispid or beset with short blunt spines in addition to the larger radial processes. It is well figured by Carpenter from a very young specimen (Introd. Foram., pl. xiv. figs. 6, 7). Egger gives a drawing of a relatively minute Rotalian shell, with precisely similar condition of surface, under the name *Rosalina horrida* (Neues Jahrb. für Min., &c., 1857, p. 278, pl. viii. figs. 14–16): and it is possible that this, which is taken from a Miocene fossil, may also represent the same form at a very early stage of growth.

Calcarina hispida has been observed at ten Stations, all of them amongst the islands of the Pacific. One of these has a depth of 155 fathoms, the remainder range from 3 fathoms or less to 37 fathoms.

Calcarina defrancii, d'Orbigny (Pl. CVIII. fig. 6, *a.b.c.*).

Calcarina defrancii, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 276, pl. xiii. figs. 5–7.
„ *spengleri*, var., Parker and Jones, 1863, Ann. and Mag. Nat. Hist., ser. 3, vol. xii. p. 439, No. 6.

The figured specimen (Pl. CVIII. fig. 6) corresponds with tolerable accuracy to d'Orbigny's drawings of *Calcarina defrancii*—the most recognisable perhaps of the passage-forms between *Rotalia* and *Calcarina*.

The shell of this variety, though often considerably thickened, does not display the same development of the supplemental skeleton as that of the typical *Calcarina spengleri;* but the long furrowed spines and the obscure irregular aperture point to a general similarity of structure.

The best examples of *Calcarina defrancii* in the Challenger collections have been found associated with the type, at one or two Stations in the Eastern Archipelago, notably off the Admiralty Islands, 15 to 25 fathoms.

Sub-family 3. Tinoporinæ.

Tinoporus [Montfort?] Carpenter.

Tinoporus, Montfort [1808], Carpenter, Carter, Moebius, Brady.
Orbitolina, pars, Parker and Jones [1860].

It is perhaps needless now to inquire whether the rude drawing given by de Montfort in the Conchyliologie Systématique, under the name *Tinoporus baculatus*, was intended, as Carpenter thinks, for the present type, or, as maintained by Carter, for a variety of *Calcarina;* or whether it is merely "a curious hybrid picture," as stated by Parker and Jones. It is agreed on all hands that the figure itself is of little or no scientific value; and the acceptance of the term in the sense in which it is now understood is due to Carpenter's elaborate account of the organism for which he employed de Montfort's name. It may, however, be added that the original printed description, so far as it goes, is in harmony with Dr. Carpenter's view.

The genus *Tinoporus*, as defined in the Introduction to the Study of the Foraminifera, includes a group of the Rotalidæ, both free and adherent, characterised by the acervuline massing of the chambers, and the absence of any specialised mouth or general aperture. Some of these forms possess a supplemental skeleton, which reveals itself externally in tubercles and marginal spines, whilst others have no accessory structures of that sort.

The series has since been divided by Carter into two sections, the term *Tinoporus* being retained for the *Calcarina*-like forms, the simpler varieties constituting a separate genus *Gypsina*. This arrangement may be accepted, but with some reservation as to name, inasmuch as it is by no means clear why Schultze's term *Acervulina* should not take precedence for the latter group.

The typical external aspect of the test of *Tinoporus* is that of a biconvex disk with radiating points or spines, the spines being placed at approximately regular intervals on the median line. Sometimes the test is more gibbous, occasionally nearly globular; and in such cases the spines are not confined to one plane, but are projected from different parts of the surface. The exterior of the test is areolated or reticulated. The areolæ, which are angular and of nearly even size, but of variable shape, are bounded by the slightly limbate sutures of the superficial chambers; and the surface is studded with raised tubercles, which are pretty evenly distributed, occupying the angles of some of the meshes. The marginal spines are usually from three to eight in number; they are straight, and taper towards the outer extremity, which is rounded or subacute; and they are marked superficially with longitudinal furrows.

The external features of the test yield only a partial indication of its internal structure. When examined by means of sections, it is found that the centre of the shell is occupied by a sort of nucleus, consisting of a few chambers arranged spirally on one plane, and that the remainder, that is to say, by far the largest part of the whole, is built up of a multitude of cells of slightly different form, disposed in more or less regular layers or tiers. The outer wall of each cell or chamber is coarsely foraminated; whilst the partitions by which they are separated consist of solid shelly plates, the lateral connection between the adjacent chambers being maintained by small stoloniferous orifices. The walls of the earlier chambers are considerably thickened, the additional deposit forming the commencement of the supplemental skeleton. This is subsequently developed more particularly at certain points, extending radially towards the margin, and eventually producing the peripheral spines; and the whole is traversed by a system of branching canals similar to that of *Calcarina*. Interposed amongst the vertical piles of chambers are a number of pillars of solid shell-substance, which serve to strengthen the framework of the shell; and the ends of these form the superficial tubercles already referred to.

Taken in its restricted sense, the genus *Tinoporus* is represented by a single species.

Tinoporus baculatus [Montfort ?], Carpenter (Pl. CI. figs. 4–7)

Tinoporous baculatus (?), Montfort, 1808, Conchyl. Syst., vol. i. p. 146, 37e genre.
Orbitolina sphærulata, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. vi. p. 33, No. 8.
Tinoporus baculatus, Carpenter, 1860, Phil. Trans., p. 557, pls. xviii., xxi.
„ „ Id. 1862, Introd. Foram., p. 226, pl. xv. figs. 5–12.
„ „ Moebius, 1878, Bau des Eozoon, p. 186, pl. xxxviii.

The generic description already furnished applies in all respects to the present species, and leaves little to be added beyond a few particulars as to distribution.

Tinoporus baculatus is not uncommon amongst the islands of the Pacific, from Tasmania northwards, at any rate as far as the Philippines; and in favourable situations it is said to exist in enormous abundance. It has only been met with at six Challenger Stations, namely:—off Fiji, 12 fathoms; at four points to the south of Papua, 6 fathoms to 155 fathoms; and off the Admiralty Islands, 15 to 35 fathoms. It occurs also on the shores of New Zealand, Australia, and the Samoa Islands, and, as before stated, Tasmania and the Philippine Islands.

Gypsina, Carter.

Millepora, pars, Phillips [1829], Woodward.
Ceriopora, pars, Michelin [1844], Reuss.
Tragos, Reuss [1845].
Coscinopora, d'Orbigny [1852], Morris, Phillips.
Acervulina, pars, Schultze [1854].
Orbitolina, pars, Parker and Jones, [1860].
Tinoporus, pars, Carpenter [1860], Brady, Robertson, Wright, Carter, Karrer, Siddall, Terrigi.
Polytrema, pars, Brady [1866], Carter.
Cellepora, Parfitt [1872].
Gypsina, Carter [1877], Brady.

The separation of *Gypsina* from *Tinoporus* is based upon negative characters, namely, the absence of peripheral spines and of the supplemental skeleton of which the spines are a development.

Gypsina is one of the simplest types of polythalamous Foraminifera. The test is either free or adherent; in the former case it may be spherical, subconical, or compressed, in the latter it forms either a tolerably symmetrical convex mass or an irregular crust, adapting itself to the contour of the body upon which it grows. It is composed of a congeries of minute chambers, of rounded, polygonal, or irregular shape, variously combined. In the more typical forms a few of the earlier chambers are arranged in a flat spire, but for the most part no regular plan of structure is discernible. The exposed surfaces of the chambers are coarsely porous, and in the absence of larger specialised

orifices the pore-canals appear to serve both for the passage of the sarcode stolons connecting the segments and as the general aperture of the test.

The living representatives of the genus affect the shallow zones of temperate and tropical seas, and are seldom found at greater depths than 400 fathoms. Fossil examples are met with in various deposits of Miocene and Pliocene age.

Gypsina globulus, Reuss, sp. (Pl. CI. fig. 8).

Ceriopora globulus, Reuss, 1847, Haidinger's Naturw. Abhandl., vol. ii. p. 33, pl. v. fig. 7.
Orbitolina lævis, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. vi. p. 31, No. 7.
Tinoporus pilaris, Brady, 1876, Ann. Soc. malac. Belg., vol. xi. p. 103.
„ *baculatus*, var. *sphæroidalis*, Carter, 1877, Ann. and Mag. Nat Hist., ser. 4, vol. xix. p. 215, pl. xiii. figs. 18, 20.
Gypsina vesicularis, var. *sphæroidalis*, Id. 1877, Ibid., vol. xx. p. 173.

The descriptive terms employed by Reuss for the present species, as well as the figures which accompany them, particularise the spherical contour of the little fossils to which they refer. The name, however, has been used by Continental writers in a somewhat wider sense, to include also the less regular varieties with rounded outline, whether subconical, oval, or compressed, some of which are provided for by *Gypsina vesicularis* and *Gypsina inhærens*. As compared with these, the recent specimens of the typical globular form are of smaller size, the superficial areolation of the test is more regularly polygonal, though not so strongly marked, and the perforation of the walls is finer and less conspicuous externally. These are the only characters on which a distinction can be founded, and they are of very little zoological value.

Mr. Carter is probably quite correct in his suggestion that the Miocene fossil described by myself some years ago under the name *Tinoporus pilaris*, may belong to the present species. The comparatively large dimensions of the test, $\frac{1}{6}$th inch (4 mm.) diameter, or even more, and the nearly or sometimes quite smooth and structureless exterior, led me at first to suppose that it was specifically distinct.

Gypsina globulus is seldom found except in company with *Gypsina vesicularis;* but though the geographical distribution of the two forms is coextensive, the latter is much more abundant. They occur together in the coral-sands of warm latitudes, at depths ranging from the littoral zone to about 400 fathoms. Small examples are occasionally met with on the northern and western shores of the British Islands.

Both have been obtained in the fossil condition from the Miocene formations of Austria and Hungary, Malta, and Jamaica; and from the Pliocene of Costa Rica; and, according to Parker and Jones, from "the Tertiary beds of Palermo, Bordeaux, and San Domingo."

Gypsina vesicularis, Parker and Jones, sp. (Pl. CI. figs. 9–12).

Orbitolina vesicularis, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. vi. p. 31, No. 5.
„ „ var. *congesta*, Id. Ibid. p. 32,—No. 6.
Tinoporus lævis, Carpenter, 1860, Phil. Trans., p. 559, pl. xxi. figs. 1–3.
„ *vesicularis*, Id. 1862, Introd. Foram., p. 224, pl. xv. figs. 1–4.
„ *lævis*, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 470, pl. xlviii. fig. 17.
Gypsina vesicularis, Carter, 1877, Ann. and Mag. Nat. Hist., ser. 4, vol. xx. p. 173.

The external aspect of this variety is sufficiently illustrated by the drawings (Pl. CI. figs. 9–11). The test is convex or subconical, frequently taking the form of a truncated cone like the lower half of a sugar-loaf. The exterior is marked by an irregular network of raised lines, which indicate the boundaries of the constituent chambers. The raised bands are generally composed of clear shell-substance, whilst the enclosed areolæ are somewhat coarsely foraminated. The internal structure, which is shown in the transparent section (fig. 12), differs in no important respect from that of *Gypsina globulus*.

As already stated, the distribution, whether geographical or geological, is practically the same as that of the allied form.

Gypsina inhærens, Schultze, sp. (Pl. CII. figs. 1–6).

Acervulina inhærens, Schultze, 1854, Organ. der Polythal. p. 68, pl. vi. fig. 12.
Polytrema, sp., Brady, 1866, Report Brit. Assoc., Trans., p. 70.
Tinoporus lucidus, Id., 1870, Edin. Catal. Brit. Foram., p. 8.
Cellepora hemisphærica, Parfitt, 1873, Ann. and Mag. Nat. Hist., ser. 4, vol. xii. p. 98, pl. iii. *b*. figs. 1–6.
Tinoporus lucidus, Robertson, 1874, Trans. Geol. Soc. Glasgow, vol. i. pt. 1, table.
„ „ Wright, 1877, Proc. Belfast Nat. Field Club, 1876–7, App., p. 105, pl. iv. figs. 4, 5.
„ „ Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 213, pl. iv. fig. 70.

Gypsina inhærens is the commonest parasitic modification of the type. The test consists of a variable number of inflated or vesicular chambers, associated either in a convex, acervuline, nearly circular mass, or in an irregular patch spreading over the surface of the object to which it happens to be attached. As in the congeneric forms, there is often a small nucleus of spirally-arranged chambers. This is sometimes visible on the adherent face of the test, but more frequently it is placed nearer the centre, and can only be detected by means of sections (fig. 6), and in many cases it either does not exist or cannot be identified. But under all circumstances the chambers which constitute the bulk of the test, whether few, as in Schultze's figure (*loc. cit.*), or very numerous as in the drawings now furnished, are combined irregularly and without dependence on any recognisable plan of growth. The chambers have no special stoloniferous orifices, and the test exhibits no general aperture; and this peculiarity serves to distinguish the present

species from some of the wild-growing *Planorbulinæ*, such as *Planorbulina acervalis* and *Planorbulina retinaculata*.[1]

Schultze's figure of *Acervulina inhærens* represents a specimen consisting of a few large, coarsely perforated, convex, adherent chambers, which when living and filled with sarcode were of a pink hue. Although hitherto overlooked, there can be no doubt that the organism referred to pertains to the species under discussion, and precedence must therefore be given to the specific name under which it was described.

Gypsina inhærens is a tolerably common shallow-water Foraminifer. It was only collected at two Challenger Stations:—off East Moncœur Island, Bass Strait, 38 fathoms; and off Booby Island, south of New Guinea, 6 fathoms; but it is a familiar object at many points on the European coast-line.

There appears to be no record of its occurrence as a fossil.

Polytrema, Risso.

Millepora, pars, Linné [1788], Esper, Lamarck.
Polytrema, Risso [1826], Blainville, Dujardin, Jones and Parker, Morris and Quekett, Carpenter, Schultze, Allman, Norman, Carter, Brady, Moebius.
Pustularia, Gray [1858].

The little red parasitic organism, familiar under the name *Polytrema miniaceum*, has a peculiar interest, not only on account of its striking external resemblance to certain corals, but from its morphological relations with some allied types of Foraminifera. It was naturally regarded by the earlier writers as a "Zoophyte," and invariably classed by them either amongst Corals or Polyzoa. Its true zoological character and position were first determined by the French naturalist Dujardin, about the year 1841; and since that time the structural features of the test, as well as the nature of the animal inhabiting it, have been more or less minutely studied by Carpenter, Schultze, Allman, Carter, and Moebius.

The test of *Polytrema* is adherent, and in its typical aspect has the form of an irregularly convex tuberculated or arborescent mass, somewhat spreading at the base; with conspicuous orifices on its free surface, which are often situated in papillæ or in elongated simple or branched tubes. The exterior is areolated in various ways, and the colour of the shell is generally some shade of red. The internal structure bears considerable analogy to that of *Gypsina*, the test being composed of a multitude of small chambers, arranged spirally just at the commencement, but subsequently in more or less regular layers. The subdivision into chambers, however, is seldom quite complete or uniform; and in arborescent specimens the centre of the branches is occupied by

[1] Parker and Jones state that "on *Chama gigas* there is often a wild-growing parasitic *Tinoporus* isomorphous with *Planorbulina retinaculata*, but still larger," *Phil. Trans.*, vol. clv. p. 381;— probably the present species.

non-segmented or only partially segmented spaces, forming tubular lacunæ, the open ends of which are seen externally in the large, irregular, terminal orifices. The walls, except near the ends of the branching processes, are thick and laminated, and those of the outer faces of the chambers coarsely perforated, as in *Gypsina*. Owing to its parasitic habit, *Polytrema* is often associated with Sponges, and the terminal openings of the lacunæ are not unfrequently armed with a brush of siliceous spicula of various shapes, either entire or broken.

The nature of the red colouring matter of the test of *Polytrema* does not appear to have been specially investigated; but a few preliminary experiments suggest that it is an organic substance, and probably identical with that found by Merejkowsky in a large number of marine organisms, and named by him Zoonerythrine.

The genus is best known by its typical species, *Polytrema miniaceum*, but Carter has described two other specific or subspecific modifications, namely, *Polytrema cylindricum* (Ann. and Mag. Nat. Hist., ser. 5, vol. v. p. 441, pl. xviii. fig. 1, *a.–g.*), and *Polytrema mesentericum* (*Ibid.*, p. 444, pl. xviii. fig. 3, *a.–h.*). The former of these is stated to be "erect, cylindrical, consisting of a thick round pillar developed from a slightly expanded base, dichotomously divided at the free end into two short thick branches, which are equal in length and opposite, terminating respectively in an expansion, from the centre of which radiate a number of more or less fragmentary sponge spicules * * * * * * Cells at the ends of the branches bearing respectively a large aperture, similar in form, position, and margination to that of the cells of *Planorbulina*, which they further resemble in the form of their pore-tubulation," &c. *Polytrema mesentericum*, the description of which is based upon a large "rolled specimen," has a "massive test, composed of more or less erect, thick, meandering laminæ united mesenterically."

The genus *Polytrema* is most abundant within the tropics, but extends as far north as the Mediterranean and the Azores, and southwards to the southern shores of Australia. It is commonest in shallow water or at moderate depths, but is occasionally met with as low down as 900 or 1000 fathoms. Little can be said with certainty as to its occurrence as a fossil. In the index of the Prodrome de Paléontologie, d'Orbigny enumerates upwards of fifty species of *Polytrema*, some of which appear under the genus *Ceriopora* in the body of the work, the whole of course being classed with Zoophytes. The geological range of these extends from the Devonian to the later Miocene or Pliocene period. Without a re-examination of the specimens, it is impossible to say how many of the species belong to the genus as at present constituted. In some of the Carboniferous Limestone shales of Scotland and the north of England there occurs a parasitic organism, *Stacheia polytrematoides*,[1] which closely resembles *Polytrema* both as to external configuration and minute structure; and it is by no means unlikely that further research may show that the relationship is even nearer than its name suggests.

[1] See — Monogr. Carb. and Perm. Foram., p. 118, pl. ix. figs. 9–13.

Polytrema miniaceum, Linné, sp. (Pl. C. figs. 5–9 ; Pl. CI. fig. 1).

Millepora miniacea, Linné, 1788, Syst. Nat., 13th (Gmelin's) ed., vol. i. pt. 6, p. 3784, No. 6.
„ „ Esper, 1797, Zooph., vol. i., pl. xvii.
„ *rubra*, Lamarck, 1816, Anim. s. Vert., vol. ii. p. 202.
Polytrema corallina, Risso, 1826, Hist. Nat. Europ. Mérid., vol. v. p. 340, No. 19.
„ *miniaceum*, Blainville, 1826, Dict. Sci. Nat., vol. xlii.;—Atlas Zooph., vol. i. p. 17.
„ „ Id. 1834, Actinologie, pp. 410, 673, pl. lxix. figs. 4, 4*a*.
„ *rubra*, Dujardin, 1841, Hist. Nat. Zooph. Infus., p. 259.
Pustularia rosea, Gray, 1858, Proc. Zool. Soc. Lond., vol. xxvi. p. 271.
Polytrema miniacea, Carpenter, 1862, Introd. Foram., p. 235, pl. xiii. figs. 18–20.
„ *miniaceum*, Schultze, 1863, Wiegmann's Archiv, p. 81, pl. viii.
„ „ Allman, 1870, Ann. and Mag. Nat Hist., ser 4, vol. v. p 372.
„ „ Carter, 1876, Ann. and Mag. Nat. Hist., ser. 4, vol. xvii. p. 185, pl. xiii. figs 1–6.
„ „ Moebius, 1880, Foram. von Mauritius, p. 85, pl. vii.

The salient characters of *Polytrema miniaceum* have been sufficiently described in the foregoing notice of the genus, of which it is the recognised type.

The Challenger dredgings, so far as they have passed through my hands, have not proved so rich in the present species as might have been anticipated ; but it is probable that finer specimens than any that have been observed amongst the coarse sands might be found adherent to corals, bivalve shells, and other similar objects, the parasitic organisms of which have not been specially examined.

Polytrema miniaceum is common in the tropical and subtropical seas of both hemispheres, its area of distribution extending from about 45° north to 35° or 40° south of the equator. Its home is in the shallower marginal zones, though it is not confined to such localities, three of the North Atlantic Stations at which it occurs having depths of 1000 fathoms, 1000 fathoms, and 900 fathoms respectively.

Polytrema miniaceum, var. *alba*, Carter (Pl. CI. figs. 2, 3).

Polytrema miniaceum, var. *album*, Carter, 1877, Ann. and Mag. Nat. Hist., ser. 4, vol. xix. p. 213, pl. xiii. fig. 14.

The white variety of *Polytrema* differs from the typical *Polytrema miniaceum* in nothing except colour.[1] The figured examples are of the encrusting form, and show no indications of the arborescent mode of growth beyond a few elevated papillæ ; but a very beautiful colourless specimen was dredged off the Ki Islands, 129 fathoms, which measures four-fifths of an inch (20 mm.) in diameter, and two-fifths of an inch (10 mm.) in height, and to the naked eye has all the appearance of a little branching coral. The

[1] Carter recognises also a brown variety, *Polytrema miniaceum*, var. *cinnamomum*, Ann. and Mag. Nat. Hist., ser. 4, vol. xix. p. 218, pl. xiii. fig. 15.

terminal orifices of the branches were crowded with loose sponge-spicules, which fell out on washing in a gentle stream of water.

The distribution of *Polytrema miniaceum*, var. *alba*, is probably coextensive with that of the typical red form, but numerically the specimens are comparatively scarce.

Family X. NUMMULINIDÆ.

The Family Nummulinidæ presents, as a whole, the highest phase of foraminiferal structure. It comprises a number of groups, characterised for the most part by possessing symmetrically-formed shells, usually of discoidal, lenticular, ovate, or fusiform contour, the chambers of which are arranged on a spiral plan, or occasionally in concentric zones. The shell-wall is in all cases finely tubulated, the pore-canals being as a rule of smaller diameter and more closely set than those observed in any other family of Foraminifera. In the more highly organised members of three Sub-families (or four if the Eozoönin*æ* be included) the test has a supplemental skeleton, variously developed, furnished with a canal system of greater or less complexity.

The Sub-family Fusulinin*æ* has no living representatives, but derives its chief interest and importance from its extraordinary abundance in Palæozoic times. It embraces a series of perforate Foraminifera having precisely the same morphological range as the porcellanous type *Alveolina*, exhibiting every gradation of contour from subglobular or even lenticular to ovate and fusiform, the latter, as in *Alveolina*, being by far the most common and characteristic. The test has no supplemental skeleton and no canal system, and its minute structure appears to be about on the same level as *Nonionina* or *Amphistegina*, its bilateral symmetry and the form and position of the aperture suggesting an affinity to the former rather than the latter genus.

The genus *Nonionina* displays the simplest structural features of the Polystomellin*æ*,—a nautiloid shell with arched slit-shaped orifice. There is no supplemental skeleton, and almost the only salient peculiarity is the thickening of the shell-wall externally over the umbilical ends of the septal lines, so as to produce a sort of stellate sutural limbation; and this is not by any means an invariable character. The varieties of *Nonionina* lead by insensible degrees to the genus *Polystomella*, the test of which becomes variously modified by the development to a greater or less extent of a supplemental skeleton. In some of the *Polystomellæ* the sutures are marked externally by minute orifices, which are the ends of the interseptal canals; whilst in others the septal furrows are bridged over at intervals, and the canals open into the fossettes between the bridges. The aperture, which in the feebler varieties resembles that of *Nonionina*, becomes divided in more typical examples, and appears as an arched or V-shaped row of pores.

Turning now to the NUMMULITINÆ,—the little Carboniferous fossil, *Archædiscus*, exemplifies the lowest type of Nummuline structure, and stands in very much the same relation to the genus *Nummulites* that *Spirillina* bears to the higher Rotalines. The shell is lenticular, and consists of a non-segmented tube of gradually increasing diameter, coiled upon itself somewhat unsymmetrically. The wall of the tube is extended laterally over the two faces of the test in the same way as the alar prolongations of the chambers of the true Nummulite. There is no secondary skeleton, but the walls are thick and laminated and finely tubulated. The genus *Amphistegina* presents a structure considerably in advance of *Archædiscus*, corresponding with that of *Pulvinulina* in the Rotaline group. The test is lenticular, the two faces being unequally convex; the segments are narrow and equitant, but their alar extensions on the inferior side are each divided into two portions by a deep constriction, so that the umbilical ends form a series of distinct lobes. The aperture resembles that of the *Rotalinæ*,—an arched fissure at the inner margin of the final segment on the inferior side. The typical aspect of the genus *Operculina* is that of a thin, complanate, planospiral shell of somewhat large dimensions, the convolutions of which are all visible externally, though the earlier ones are more or less embracing; the chambers are usually very numerous, narrow, and undivided, and the aperture a simple cleft at the inner margin of the terminal segment. *Heterostegina* displays similar general features, but the chambers are subdivided by transverse septa, and the aperture takes the form of a row of pores on the exposed septal face. The genus *Nummulites* is closely related to *Operculina*, but exhibits a further advance in structure and organisation. The true Nummulite has a discoidal test, the two faces of which are as a rule equally convex, formed of several convolutions, each of which completely invests its predecessor. The spire does not increase in diameter so rapidly or so regularly as that of *Operculina*, and in the larger varieties the final convolution becomes gradually contracted at its peripheral margin, until it closes in the shell. The septa are double, and are traversed by a system of canals, which communicates with that of the marginal portion of the supplemental skeleton.

The two genera constituting the Sub-family CYCLOCLYPEINÆ afford instances of an annular instead of a spiral mode of growth. The test both of *Cycloclypeus* and *Orbitoides* is discoidal and bilaterally symmetrical, and either lenticular in contour or complanate and thickened only at the centre. It consists primarily of a median layer composed of chamberlets arranged in concentric zones. In *Cycloclypeus* this median plane of chambers is thickened on both sides, chiefly near the middle, by layers of finely tubulated shell substance; whilst the test of *Orbitoides* presents similar lateral masses, composed of layers of minute chamberlets irregularly combined. In either case the canal system is traceable both through the central and superficial portions of the shell.

Concerning *Eozoön* and the provisionally constituted Sub-family EOZOÖNINÆ, it is needless to speak, so long as the claim of the former to be ranked as a member of the animal

kingdom is a matter of controversy. It is regarded by Dawson and Carpenter as a massive sessile Foraminifer, composed of acervuline layers, and endowed with a supplementary skeleton and a system of ramifying canals.

Sub-family 1. Fusulininæ.

This Sub-family has no living representatives, the species which it embraces being fossils, for the most part of Carboniferous age.

Sub-family 2. Polystomellinæ.

Nonionina, d'Orbigny.

Nautilus, pars, Walker and Boys [1784], Adams, Walker and Jacob, Fichtel and Moll, Montagu, Maton and Rackett, Pennant, Turton, Wood, Fleming.
Chrysolus, *Florilus*, *Nonion*, Montfort [1808].
Melonis, Montfort [1808], Blainville.
Pulvinulus, pars, Lamarck [1816].
Placentula, pars, Lamarck [1822], Defrance.
Cristellaria, pars, Lamarck [1822].
Lenticulina, pars, Defrance [1824], Blainville.
Polystomella, pars, Defrance [1824], Blainville, Macgillivray, Thorpe, Parker and Jones.
Nonionina, d'Orbigny [1826], Roemer, Bronn, Reuss, Czjzek, Alth, Williamson, Costa, Parker and Jones, Egger, Karrer, Gümbel, Carpenter, Seguenza, Brady, M. Sars, Alcock, Dawson, &c.

The genera *Nonionina* and *Polystomella* constitute a single series of gradational forms so closely linked from end to end that even the separation into two subordinate groups is attended with certain difficulties. The general conformation and arrangement of the test are the same in both genera. It is composed of numerous segments combined in an equilateral nautiloid spire, the latest convolution of which completely encloses those preceding it; and the aperture is either an arched fissure or a row of pores placed symmetrically at the inner margin of the terminal segment, close to the line of union with the previous convolution. The walls are hyaline and distinctly, though often very finely, foraminated.

To the Nonionine group are assigned the simpler members of the series,—those, namely, which exemplify the foregoing with but few additional features.

There is, however, one point in the structure of the more typical *Nonioninæ* which it is needful to notice; and that is the tendency exhibited by certain species to develop exogenous lines of shell-substance, of greater or of less length and thickness, in the septal depressions, near the centre of the test. This "sutural limbation" is an exceedingly variable feature. There are certain species in which it is absent or hardly discernible;

in others it takes the form of a ring of round or oblong beads immediately encircling the umbilicus, whilst there are some varieties in which it has the aspect of an embossed star, with straight or curved tapering rays covering the septal lines to within a short distance of the periphery.

The orifice, the normal form of which is a simple curved fissure, often shows traces of subdivision by transverse bars, approaching in character the multiple or porous aperture of the *Polystomellæ*.

The geographical distribution of *Nonionina* is world-wide, specimens having been found in every latitude and at almost every depth at which the sea-bottom has been explored. There is no satisfactory evidence of the existence of the genus before the commencement of the Tertiary epoch;[1] but it occurs in the Eocene of the Paris Basin, and becomes gradually commoner in succeeding formations down to recent times.

Nonionina depressula, Walker and Jacob, sp. (Pl. CIX. figs. 6, 7).

"Nautilus spiralis utrinque subumbilicatus," Walker and Boys, 1784, Test. Min., p. 19, pl. iii. fig. 68.

Nautilus depressulus, Walker and Jacob, 1798, Adams's Essays, Kanmacher's Ed., p. 641, pl. xiv. fig. 33.

Nonionina perforata, d'Orbigny, 1846, For. Foss. Vien., p. 110, pl. v. figs. 17, 18.

„ *granosa*, Id. Ibid. p. 110, pl. v. figs. 19, 20

„ *punctata*, Id. Ibid. p. 111, pl. v. figs. 21, 22.

„ *umbilicatula*, Williamson, 1858, Rec. For. Gt. Br., p. 97, pl. iv. figs. 70, 71.

„ *crassula*, Id. Ibid. p. 33.

„ *asterizans*, var. *depressula*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 310.

Polystomella crispa, var. (*Nonionina*) *depressula*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 403, pl. xiv. fig. 39, *a.b.*

Nonionina crassula, Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 396, No. 43.

„ *granosa*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III., p. 43, pl. ii. fig. 10, *a.b.*

The test of *Nonionina depressula* is much compressed, and the peripheral edge round; the umbilici are nearly flush, that is to say, they are neither much excavated nor umbonate, nor do they exhibit any amount of sutural limbation; the segments are somewhat inflated and the margin more or less lobulated; the shell-wall is usually very thin and hyaline.

As compared with the allied forms, the characters of *Nonionina depressula* are those of a starved variety, and the conditions under which it is found support this view. It

[1] Reuss, in his memoir on the Classification of the Foraminifera, states the geological range of the genus as "the Silurian formation (?), the Carboniferous Limestone, and from the Chalk forwards" (*Sitzungsb. d. k. Ak. Wiss. Wien*, 1861, vol. xliv. p. 389). The first of these is quoted interrogatively, and may be dismissed as wanting confirmation. The Carboniferous specimens referred to are almost certainly forms now assigned to the genus *Endothyra*; and those from the Chalk are probably *Pullenieæ* which were included by d'Orbigny, and at that time by Reuss also, in the genus *Nonionina*.

has been observed in the Arctic Seas, as far north as lat. 82° 33′ N., and it is abundant on the European shores of the North Atlantic. Though less common within the tropics, it occurs from time to time amongst the islands of the South Pacific, in the South Atlantic, the Red Sea, and elsewhere. Notwithstanding that a few poorly-characterised specimens have been met at the greater depths of the ocean, the home of the species is on bottoms of less than 50 fathoms, and it is the only member of the genus that is common in estuaries and brackish-water pools.

Under one name or other the form has been identified in the Eocene formation of Paris (Terquem), in the Miocene of Vienna (d'Orbigny), and of Calabria (Seguenza); in the Pliocene of the Island of Rhodes (Terquem), and in the Post-tertiaries of Norway (Sars, Crosskey, and Robertson), and of various parts of the British Islands (Robertson, Wright, Shone).

Nonionina umbilicatula, Montagu, sp. (Pl. CIX. figs. 8, 9).

Nautilus umbilicatulus, Montagu, 1803, Test. Brit., p. 191;—Suppl., p. 78, pl. xviii. fig. 1.
Nonionina soldanii, d'Orbigny, 1846, For. Foss. Vien., p. 109, pl. v. figs. 15, 16.
„ „ Costa, 1856, Atti dell' Accad. Pontan., vol. vii. p. 201, pl. xvii. fig. 11.
„ *polystoma*, Id. Ibid. p. 206, pl. xiv. fig. 10.
„ *barleeana*, Williamson, 1858, Rec. For. Gt. Br., p. 32, pl. iv. figs. 68, 69.
Polystomella crispa, var. (*Nonionina*) *umbilicatula*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 405, pl. xiv. fig. 42, *a.b.*; pl. xvii. figs. 58, 59.
Nonionina formosa, Seguenza, 1879, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 63, pl. vii. fig. 6.
„ *umbiliçata*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii., Mém. III., p. 42, pl. ii. fig. 7.

Nonionina umbiliculata forms a good quasi-specific type, embodying characters about midway between those of *Nonionina depressula* and *Nonionina pompilioides*. From the former it is distinguished by its more compact build and deeply sunk umbilici, from the latter by its relatively depressed contour and larger number of chambers.

It is a cosmopolitan form, its area of distribution reaching from Smith Sound and the shores of Franz-Josef Land, about lat. 80° N., to the south of Patagonia, about lat. 51° S. It is abundant in the North Atlantic and South Pacific, and scarcely less so in the South Atlantic and North Pacific, and occurs also in the Indian Ocean, the Southern Ocean, the Mediterranean and the Red Sea. The bathymetrical range extends from 30 or 40 fathoms down to 3125 fathoms.

Fossil examples have been obtained from the Eocene of the Paris Basin (Terquem), from the Septaria-clay and Upper Oligocene formations of Central Europe (Reuss), from the Miocene of Vienna (d'Orbigny), and of Calabria (Seguenza); from the later Tertiaries of Italy (Costa), from the Pliocene of the Island of Rhodes (Terquem), from the Post-pliocene of Norway (Sars), and of Cheshire (Shone), and from the sub-recent Fen-clay of Cambridgeshire (Parker and Jones).

Nonionina pompilioides, Fichtel and Moll, sp. (Pl. CIX. figs. 10, 11).

"Nautilus *Melo*," Soldani, 1798, Testaceographia, vol. ii. p. 38, pl. viii. fig. *z.z. A.B.C.*
Nautilus pompilioides, Fichtel and Moll, 1803, Test. Micr., p. 31, pl. ii. figs. *a–e.*
Melonis etruscus, Montfort, 1808, Conchyl. Systém., vol. i. p. 67, xvii^e^ genre.
Polystomella etrusca, Defrance, 1824, Dict. Sci. Nat., vol. xxxii. p. 183;—Blainville, Malac. p. 389.
Nonionina umbilicata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 293, pl. xv. figs. 10–12;—Modèle, No. 86.
,, *melo*, Id. Ibid. p. 293, No. 4.
,, *pompilioides*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 18, pl. iii. fig. 98.

The term *Nonionina pompilioides* takes precedence for the subglobular modification of the type. The test is thicker than that of *Nonionina umbilicatula*, usually of somewhat smaller diameter, and with rather fewer chambers in the outer convolution; but otherwise it is built on the same compact nautiloid plan.

Nonionina pompilioides is less common than the immediately allied forms, and so far as can be learnt from the Challenger and "Porcupine" collections it appears to be almost exclusively a deep-water Foraminifer. It has been observed at seven Stations in the North Atlantic, the depths ranging between 1000 and 2750 fathoms; at one in the South Atlantic, 2200 fathoms; at two in the Southern Ocean, 1570 and 1950 fathoms; at eight in the South Pacific, 1350 to 2421 fathoms; and at two in the North Pacific, 1850 and 2250 fathoms respectively. Its occurrence in the Mediterranean and the Adriatic is also on record.

Its earliest appearance as a fossil is about the middle of the Tertiary epoch. It has been found in the Miocene deposits of Vienna, Bordeaux, Malta, and Calabria (d'Orbigny, Brady, Seguenza); and in the later Tertiary formations of Italy and the south-east of Spain (Soldani, d'Orbigny, Parker and Jones).

Nonionina orbicularis, H. B. Brady (Pl. CIX. figs. 20, 21).

Nonionina orbicularis, Brady, 1881, Denkschr. d. k. Akad. Wiss. Wien, vol. xliii. p. 105, pl. ii. fig. 5, *a.b.*;—Ann. and Mag. Nat. Hist., ser. 5, vol. viii. p. 415, pl. xxi. fig. 5, *a.b.*

Test subglobular, somewhat compressed, convex or slightly umbonate at the umbilici; peripheral edge round, and faintly lobulated: segments numerous, about ten in the final convolution; sutural lines more or less excavated near the umbilici. Aperture arcuate; either simple, or partially divided by teeth projecting from the upper margin. Diameter, about $\frac{1}{35}$th inch (0·75 mm.).

This species resembles *Nonionina pompilioides* in its subspherical contour, but may be distinguished by its larger number of segments and their less regular disposition, as well as by the thickened umbilici. The aperture, like that of some of the weaker forms of *Polystomella*, is sometimes notched, or partially bridged over by projecting teeth.

Nonionina orbicularis has been dredged on the west coast of Novaya Zemlya, 55 fathoms; on the shores of Spitzbergen, 7 fathoms; in the Faröe Channel, 632 fathoms; on the west of Scotland, 25 fathoms; and off Valentia, 112 fathoms.

Fossil specimens have been identified amongst the microzoa from a Post-tertiary clay occurring on the coast of Fifeshire.

Nonionina asterizans, Fichtel and Moll, sp. (Pl. CIX. figs. 1, 2).

Nautilus asterizans, Fichtel and Moll, 1803, Test. Micr., p. 37, pl. iii. figs. *e–h*.
Florilus stellatus, Montfort, 1808, Conchyl. Systém., vol. i. p. 135, xxxiv$_e$ genre.
Pulvinulus asterizans, Lamarck, 1816, Tab. Encycl. et Méthod., pt. xxiii. pl. 466, fig. 10, *a–d*.
Placentula asterizans, Id. 1822, Anim. s. Vert., p. 621, No. 2.
Nonionina asterizans, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 101, No. 1.
Polystomella crispa, var. (*Nonionina*) *asterizans*, Id., 1865, Phil. Trans., vol. clv. p. 403, pl. xiv. fig. 35, pl. xvii. fig. 54.

The *Nautilus asterizans* of Fichtel and Moll has been selected by Parker and Jones as the type of the Nonionine section of the *Polystomellinæ*. The original figure is that of a regularly nautiloid shell, the sutural limbation of which is well marked but confined to a small area immediately encircling the umbilicus, the umbilicus itself being slightly excavated.

Characteristic specimens of this sort have been obtained from sands dredged off Kandavu, Fiji Islands, at depths of 210 fathoms and 255 fathoms, and off Raine Island, 155 fathoms. The species is recorded by Parker and Jones from the Red Sea, the Indian Ocean, the coast of Australia and elsewhere.

The same authors report its occurrence in the later Tertiaries of Italy, and in the Fen-clays of Lincolnshire and Cambridgeshire. It has also been found by Crosskey and Robertson in the Post-tertiaries of Norway and the west of Scotland, and by Shone in the Glacial-clays of Cheshire.

Nonionina stelligera, d'Orbigny (Pl. CIX. figs. 3–5).

Nonionina stelligera, d'Orbigny, 1839, Foram. Canaries, p. 128, pl. iii. figs. 1, 2 ("*stellifera*" on plate).
„ „ Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 471, pl. xlviii. fig. 19.
Polystomella crispa, var. (*Nonionina*) *stelligera*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 404, pl. xiv. figs. 40, 41.
Nonionina stellifera, Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 397, No. 46.
„ *stellata*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 43, pl. i. fig. 11, *a.b*.

The general form of the test of *Nonionina stelligera* is similar to that of *Nonionina depressula*, with which it also agrees as to the shape and disposition of the segments. The

species is primarily characterised by the stellate sutural limbation, consisting of long, curved, or sometimes abruptly bent, raised lines of shell-substance, radiating from the umbilici—the rays broadest and most turgid near the centre, and tapering towards their peripheral ends.

Well-marked specimens of *Nonionina stelligera* are not very abundant. They have been found in the Arctic Seas,—in Smith Sound, as far north as lat. 82° 33′ N., and on the shores of Spitzbergen, Franz-Joseph Land, and Novaya Zemlya; at three "Porcupine" Stations in the North Atlantic, depth 64 fathoms to 155 fathoms; and sparingly on the British and French coasts; in shore-sand from the Canaries; off Ascension Island, 420 fathoms; in the Mediterranean; and at three points on the west coast of Patagonia, at depths of 125 to 245 fathoms.

The species has been observed amongst the fossil microzoa of the Eocene of Paris (Terquem); the later Italian Tertiaries (Parker and Jones); and the Post-tertiaries of the west of Scotland (Robertson).

Nonionina boueana, d'Orbigny (Pl. CIX. figs. 12, 13).

Nonionina boueana, d'Orbigny, 1864, For. Foss. Vien., p. 108, pl. v. figs. 11, 12.

D'Orbigny's figure of *Nonionina boueana* represents a compressed shell, with broad oval outline and sharp peripheral edge, the segments being numerous, long, narrow, and considerably curved. The specific term is one very generally employed by Continental Rhizopodists, and may be accepted as a name of convenience for a group of forms allied to *Nonionina scapha*, but differing from that species in their relatively compressed contour and larger number of chambers.

Reuss treats the *Nonionina communis* of d'Orbigny (For. Foss. Vien., p. 108, pl. v. figs. 7, 8) as synonymous with *Nonionina boueana* (Sitzungsb. d. k. Ak. Wiss. Wien, 1864, vol. l. p. 479, No. 5); Parker and Jones, on the other hand, assign the former to *Nonionina scapha*, F. and M., sp. (Phil. Trans., vol. clv. p. 404). In point of fact, *Nonionina communis* forms an intermediate link almost equally related to both varieties.

Notes have been kept of the occurrence of *Nonionina boueana* at the following points:—Vigo Bay, 11 fathoms; off Cezimbra, 50 fathoms; Bay of Biscay, 180 to 200 fathoms; Red Sea, 10 to 15 fathoms; off Amboyna, 15 to 20 fathoms; Hong Kong Harbour, 7 fathoms; and west coast of Patagonia 125 fathoms.

Fossil specimens are recorded from the Septaria-clay and Upper Oligocene formations of Germany (Reuss); and the Miocene of the Vienna Basin, and of Southern Italy (d'Orbigny, Seguenza).

Nonionina boueana, var. *armata*, nov. (Pl. CXV. fig. 9, *a.b.*).

This is an interesting modification, closely resembling *Nonionina boueana*, both as to contour and segmentation; but the portion of the peripheral edge extending from the inner margin of the final segment, about one-fourth round the shell, is armed with short truncated spines.

It is a local variety, somewhat abundant amongst the littoral sand of the east coast of Madagascar, and has not, so far as I know, been observed elsewhere.

Nonionina scapha, Fichtel and Moll, sp. (Pl. CIX. figs. 14, 15; and 16 ?).

Nautilus scapha, Fichtel and Moll, 1803, Test. Micr., p. 105, pl. xix. figs. *d.–f.*
Nonionina sloani, d'Orbigny, 1839, Foram. Cuba, p. 68, pl. vi. fig. 18.
„ *scapha*, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 102, No. 4.
„ *boueana*, Reuss, 1863, Bull. Acad. Roy. Belg., ser. 2, vol. xv. p. 156, pl. iii. figs. 47, 48.
„ *scapha*, Brady, 1865, Nat. Hist. Trans. Northd. and Durham, vol. i. p. 106, pl. xii. fig. 10, *a.b.*
Polystomella crispa, var. (*Nonionina*) *scapha*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 404, pl. xiv. figs. 37, 38, pl. xvii. figs. 55, 56.

The test of *Nonionina scapha* is of elongate oval contour, and more or less compressed, the peculiar form being due to the rapid increase in size of the later segments. This increase is not merely in the length of the chambers, but also in their thickness. The peripheral edge of the later portion of the test is obtuse or rounded, and the exposed septal face of the final segment varies from broadly oval to more or less cordate.

A thick variety of this species, with extremely broad, cordate, septal face, has been described by Dawson under the name *Nonionina labradorica* (Canad. Nat., 1860, vol. v. p. 192, woodcut, fig. 4).

Nonionina scapha is a very widely diffused Foraminifer. It is abundant in the Arctic Seas, reaching to the furthest points yet explored, namely, to lat. 83° 19′ N. in the western, and about lat. 80° N. in the eastern hemisphere. It is common on the western shores of Europe, and has been taken at twelve points in the North Atlantic, at various depths down to 1360 fathoms. It is equally common amongst the islands on the west coast of Patagonia, and occurs in other parts of the South Pacific down to 1375 fathoms. It is less frequent in the North Pacific (three Stations, 7 to 345 fathoms), and comparatively rare in the South Atlantic, the Mediterranean, and the Red Sea. I am not aware that it has been met with either in the Indian or the Southern Ocean.

Fossil specimens have been obtained from the Miocene of Calabria (Seguenza), and of the Vienna Basin (d'Orbigny); from the Pliocene of various parts of Italy, and of the

vicinity of Malaga (Parker and Jones, Seguenza); from the Crag of Antwerp (Reuss), and of Norfolk and Suffolk (Jones, Parker, and Brady); and from the Post-tertiaries of Norway, Scotland, Ireland, Canada, and elsewhere (Crosskey and Robertson, Wright, &c.).

Nonionina turgida, Williamson, sp. (Pl. CIX. figs. 17–19).

Rotalina turgida, Williamson, 1858, Rec. For. Gt. Br., p. 50, pl. iv. figs. 95–97.
Nonionina asterizans, var. *turgida*, Parker and Jones, 1862, Introd. Foram., Appendix, p. 311.
Rotalia cristellarioides, Reuss, 1863, Bull. Acad. Roy. Belg., ser. 2, vol. xv. p. 154, pl. iii. fig. 44.
Nonionina turgida, Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 474, No. 91.
Polystomella crispa, var. (*Nonionina*) *turgida*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 405, pl. xvii. fig. 57, *a.b.c.*

The large, embracing, final segment, which often occupies nearly half of the visible shell, forms the distinctive feature of *Nonionina turgida*. This chamber is frequently developed inequilaterally, and in such cases the test assumes a Rotaliform aspect, which has been an occasional source of confusion and error.

Nonionina turgida is most familiar as a shallow-water North Atlantic Foraminifer. So far as is known, its northern limit is about lat. 73° N., on the coast of Novaya Zemlya. It is not uncommon on the shores of Great Britain and France, and has been observed at thirteen Stations in the North Atlantic, the depths ranging from 11 to 1630 fathoms; at one in the South Atlantic, off the Rio de la Plata, 13 fathoms; at eight in the South Pacific, 12 to 275 fathoms; and at one in the North Pacific, off the south coast of Japan, 345 fathoms.

Fossil examples are recorded from the Crag of Antwerp (Reuss), and from the Post-tertiary beds of Norway, Scotland, and Ireland (Crosskey, Robertson, Wright).

Polystomella, Lamarck.

Nautilus, pars, Linné [1767], Walker and Boys, Adams, Fichtel and Moll, Montagu, Maton and Rackett, Pennant, Fleming, &c.
Elphidium, *Pelorus*, *Andromedes*, *Sporilus*, *Themeon*, *Cellanthus*, Montfort [1808].
Geophonus (*Geoponus*), Montfort [1808], Ehrenberg.
Vorticialis, Lamarck [1816], Defrance, Blainville.
Polystomella, Lamarck [1822], Defrance, Blainville, d'Orbigny, Bronn, Michelotti, Reuss, Czjzek, Rütimeyer, Abich, Sowerby, Costa, Egger, Parker and Jones, Williamson, Carpenter, Karrer, Moebius, &c.
Robulina, pars, Münster [1838].
Nonionina, pars, Boll [1846], Egger.
Helicoza, Moebius [1880].

The genus *Polystomella*, using the term in its common acceptation, exhibits the same general features as *Nonionina;* that is to say, the test consists of a regular, equilateral, nautiloid spire, of which the final convolution alone is visible externally. The feebler

varieties of the genus cannot be separated by any sharp lines from some of the allied *Nonioninæ*, but the more typical forms present certain additional characters which are regarded as distinctively Polystomelline. The genus has been so frequently and so carefully described by previous writers, and its structure and affinities so fully treated, that it is only needful here to draw attention to the more important external features which are of service to the systematist.

The test of *Polystomella* is, as a rule, of lenticular or discoidal form. In the weaker modifications (*e.g.*, *Polystomella striatopunctata*) the segments are more or less inflated, and the external furrows by which they are separated are bridged over at intervals by extensions of the inner margins of the segments, leaving rows of depressions or "fossettes" to mark the septal lines. These marginal extensions of the segments are called "retral processes," or in connection with their external shelly investment "septal bridges," and throughout a considerable section of the genus their presence to a greater or less extent is the only advance in structure upon that of the *Nonioninæ*.

In the more typical *Polystomellæ* the septa themselves, instead of being depressed, are limbate externally; and the retral processes are numerous and sufficiently developed to form regular series of elevated transverse ridges, almost or completely connecting the septa of the consecutive chambers. Usually in these cases the septal bands are much thicker and more elevated than the transverse ridges (*Polystomella crispa*), but sometimes they are equally developed, and form a surface-reticulation of uniform height (*Polystomella verriculata*).

The aperture of the feebler varieties consists of an arched cleft at the inner margin of the final segment, scarcely differing from that of *Nonionina;* but in other forms the superior edge or lip is denticulated, so as to subdivide the opening to a greater or less degree by cross bars, and in *Polystomella crispa* it consists of a V-shaped row of rounded orifices, which may be regarded as the typical condition.

As already stated, the test of *Polystomella* in its normal aspect is equilateral and biconvex, though individual specimens exhibiting a certain amount of bilateral asymmetry are by no means uncommon. There exists, however, a small group of forms, named by d'Orbigny *Faujasina*, in which the shell is plano-convex and the arrangement of the spire like that of *Truncatulina lobatula*, the whole of the convolutions being visible on the flat side of the test, the final convolution only on the convex face.

The more highly organised species of *Polystomella* have a supplemental skeleton, provided with a somewhat complex system of canals. The precise form and arrangement of the canals differ materially in the different species, though (broadly speaking) referrible to one general plan. Two "spiral canals," one on each face of the test, follow the umbilical edges of the spiral lamina; these are connected by "meridional" canals lying in the septal depressions between the chambers; and the latter communicate with the exterior by short tubes, single or forked, which open upon the septal lines. In the

umbonate forms and those in which the umbilical depressions are filled with clear shell-substance, that portion of the test is traversed by straight vertical canals. The openings of the canals, excepting those of the umbilical region last referred to, are seldom conspicuous on the exterior. They exist, however, in the form of single or double rows of pores upon the septal lines, and are best seen in the smooth-shelled species, like *Polystomella arctica* (Pl. CX. figs. 2–5).

The distribution of the genus *Polystomella*, whether geographical or geological, corresponds closely with that of *Nonionina;* but though the feebler varieties are occasionally met with in deep water, it belongs essentially to a shallower zone of the ocean. It also appears to reach back to an earlier geological period, having recently been found by Dr. Uhlig in formations of Middle Jurassic age.

Polystomella striatopunctata, Fichtel and Moll, sp. (Pl. CIX. figs. 22, 23).

Nautilus striatopunctatus, Fichtel and Moll, 1803, Test. Micr., p. 61, pl. ix. figs. *a–c.*
Polystomella poeyana, d'Orbigny, 1839, Foram. Cuba, p. 75, pl. vi. figs. 25, 26.
,, *articulata*, Id. 1839, Foram. Amér. Mérid., p. 30, pl. iii. figs. 9, 10.
Geoponus stella-borealis, Ehrenberg, 1839, Abhandl. d. k. Akad. Wiss. Berlin, p. 132, pl. i. figs. *a–g.*
Polystomella haucrina, d'Orbigny, 1846, For. Foss. Vien., p. 122, pl. vi. figs. 1, 2.
,, *rugosa*, Id. Ibid. p. 123, pl. vi. figs. 3, 4.
,, *obtusa*, Id. Ibid. p. 123, pl. vi. figs. 5, 6.
,, *antonina*, Id. Ibid. p. 128, pl. vi. figs. 17, 18.
,, *listeri*, Id. Ibid. p. 128, pl. vi. figs. 19–22.
,, *stella-borealis*, Schultze, 1854, Organ. Polythal., p. 67, pl. vi. figs. 5, 6.
,, *gibba*, Id. Ibid. p. 66, pl. vi. figs. 1–4.
,, *venusta*, Id. Ibid. p. 67, pl. vi. figs. 7–9.
Nonionina heteropora, Egger, 1857, Neues Jahrb. für Min., &c., p. 300, pl. xiv. figs. 19–21.
,, *dense-punctata*, Id. Ibid. p. 299, pl. xiv. figs. 22, 23.
Polystomella subcarinata, Id. Ibid. p. 301, pl. xiv. figs. 24, 25.
,, *angulata*, Id. Ibid. p. 302, pl. xv. figs. 5, 6.
,, *umbilicatula*, Williamson, 1858, Rec. For. Gt. Br., p. 42, pl. iii. figs. 81, 82.
,, ,, var. *incerta*, Id. Ibid. p. 44, pl. iii. fig. 82, *a.*
,, *inflata*, Reuss, 1860, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xlii. p. 358, pl. i. fig. 10, *a.b.*
,, *striatopunctata*, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 103, No. 6.
,, *minuta*, Reuss, 1864, Sitzungsb. d. k. Ak. Wiss. Wien, vol. l. p. 478, pl. iv. fig. 6, *a.b.*
,, *discrepans*, Id. Ibid. p. 478, pl. iv. fig. 7, *a.b.*
,, *latidorsata*, Id., 1864, Denkschr. d. k. Akad. Wiss. Wien, vol. xxiii. p. 10, pl. i. fig. 16, *a.b.*
,, *crispa*, var. *striatopunctata*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 402, pl. xiv. figs. 31–34; pl. xvii. fig. 60, *a.b.*
,, *excavata*, Terquem, 1875, Anim. sur la Plage de Dunkerque, p. 25, pl. ii. fig. 2, *a–f.*
,, *umbilicatula*, Id. Ibid. p. 25, pl. ii. fig. 3, *a.b.*

Polystomella minima, Seguenza, 1879, Atti R. Accad. dei Lincei, ser. 3, vol. vi. p. 333, pl. xvii. fig. 38.
„ *striatopunctata*, Terrigi, 1880, Atti dell' Accad. Pontif., ann. xxxiii. p. 216, pl. iv. figs. 73, 74.
„ *antonina*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. p. 47, pl. ii. fig. 25, *a.b.*

This is one of the weaker modifications in which the distinctively Polystomelline characters are only partially recognisable. The test is discoidal and equilateral, the umbilici generally, though not always, slightly depressed, and the peripheral edge rounded. The septal bridges marking the retral processes are always more or less apparent, and in good examples they are conspicuous and regularly arranged (fig. 22). The aperture is ordinarily an arched crevice, sometimes notched along the superior margin, or, more rarely, divided by transverse bars so as to form a line of small pores.

Polystomella striatopunctata is by far the most abundant and most widely dispersed variety of the genus. It is equally at home in the Arctic Ocean, the North and South Atlantic, the Mediterranean, the Adriatic, the Red Sea, the Indian and Southern Oceans, and the North and South Pacific. It stretches northwards to latitude 82° 33′ N. in Smith Sound, and to about lat. 80° N. on the shores of Franz-Joseph Land; and southwards to the Falkland Islands and Kerguelen Island. Its normal habitat is on bottoms of less than 100 fathoms, but it is not unfrequent down to about 600 fathoms, and rare specimens have been met with at six Stations, of which the depths were more than 1000 fathoms, and at two of more than 2000 fathoms.

As a fossil the species has been obtained from the Eocene of the Paris Basin (Terquem), and the Nummulitic beds of Styria (Reuss); the Upper and Lower Oligocene of Germany and France (Reuss); the Miocene of Austria and Bavaria (d'Orbigny, Egger); the later Tertiaries of Italy (Seguenza, Terrigi), the Crag of Antwerp (Reuss), and of the east of England (Jones, Parker, and Brady); and from almost every deposit of Post-tertiary age of which the microzoa have been determined.

Polystomella subnodosa, Münster, sp. (Pl. CX. fig. 1, *a.b.*).

Robulina subnodosa, Münster, 1838 (*fide* Roemer), Neues Jahrb. für Min., &c., p. 391, pl. iii. fig. 61.
Nonionina splendida, Boll, 1846, Geog. d. deutsch. Ostseeländer, p. 177, pl. ii. fig. 15.
Polystomella subnodosa, Reuss, 1855, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xviii. p. 240, pl. iv. fig. 51, *a.b.*
„ *punctata*, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i. p. 16, pl. vi. fig. 7, *a.b.*

The test of *Polystomella subnodosa* is biconvex, the periphery being sharp or

subcarinate and the umbilici turgid or slightly umbonate; the septa are more or less depressed, and the septal bridges and fossettes present exactly the same aspect as those of *Polystomella striatopunctata*.

As a living Foraminifer *Polystomella subnodosa* has only been identified at two points, amongst the islands south-west of Papua, namely:—Station 187, off Booby Island, depth 6 to 8 fathoms; and Station 188, depth 28 fathoms.

Fossil specimens occur in the Septaria-clay and the Upper and Lower Oligocene formations of various parts of Germany (Münster, Boll, Reuss) and in the Upper Pliocene of the Island of Rhodes (Terquem).

Polystomella arctica, Parker and Jones (Pl. CX. figs. 2–5).

Polystomella arctica (P. & J., MS.), Brady, 1864, Trans. Linn. Soc. Lond., vol. xxiv. p. 471, pl. xlviii. fig. 18.
,, *crispa*, var. *arctica*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 401, pl. xiv. figs. 25–30.
,, *arctica*, Brady, 1878, Ann. and Mag. Nat. Hist., ser. 5, vol. i. p. 437, pl. xxi. fig. 13, *a.d.*

The general contour of *Polystomella arctica* is similar to that of *Polystomella striatopunctata*, though the specimens of the former attain much larger dimensions. Typically the shell is discoidal, with nearly flat lateral faces and rounded periphery; the retral processes of the segments are abortive, and consequently there are no septal bridges; the sutures are nearly complanate externally, and are marked by a double row of pores, the openings of a partially developed system of interseptal canals, the two rows being often separated by a raised band of shell-substance. The walls of the test are generally much thickened, and present a laminated appearance when seen in section (fig. 4). The aperture is a crescentiform fissure more or less subdivided by denticulations of the superior edge. There are also frequent indications of a second row of orifices, parallel to the normal aperture, a little higher up on the septal face (fig. 5). The test attains a diameter of $\frac{1}{20}$th inch (1·26 mm.) or more.

Polystomella arctica is exclusively a boreal and almost exclusively an arctic species. It is common in Baffin's Bay and Smith Sound, as far north as lat. 82° 27′ N., at every depth down to 210 fathoms; off the Hunde Islands, Davis Strait, 25 to 70 fathoms; on the shores of Spitzbergen, 7 fathoms; off Franz-Joseph Land, lat. 79° to 80° N., 108 to 125 fathoms; and off Novaya Zemlya, 55 to 93 fathoms. It is comparatively rare in the Faröe Channel and the Shetland Seas; and its southern limit, so far as at present known, is reached on the western coast of Scotland.

Mr. Wright has met with specimens in the Boulder-clay of the north-east of Ireland, but it has not been found elsewhere in the fossil state.

Polystomella crispa, Linné, sp. (Pl. CX. figs. 6, 7).

"Cornu Hammonis orbiculatum," Plancus, 1739, Conch. Min., p. 10, pl. i. fig. 2.
"Nautilus minimus," Gaultieri, 1742, Index Test., pl. xix. figs. A.D.
Nautilus crispus, Linné, 1767, Syst. Nat., 12th ed., p. 1162—275.
"Nautilus spiralis geniculis crenatis," Walker and Boys, 1784, Test. Min., p. 18, pl. iii. fig. 65.
"Nautili *striati communes* (*crispi* Linnæi)," Soldani, 1789, Testaceographia, vol. i. pt. 1, p. 54, pl. xxxiv. figs. *c.c. e.e.* C.H.I.
Themeon rigatus, Montfort, 1808, Conchyl. Systém., vol. i. p. 203, 51e genre.
Polystomella crispa, Lamarck, 1822, Anim. s. Vert., vol. vii. p. 625, No. 1.
Vorticialis crispa, Defrance, 1824, Dict. Sci. Nat., vol. xxxii. p. 181.—Blainville, 1825, Malacologie, p. 375.
Polystomella oweniana, d'Orbigny, 1839, Foram. Amér. Mérid., p. 30, pl. iii. figs. 3, 4.
„ *lanieri*, Id. 1839, Foram. Cuba, p. 74, pl. vii. figs. 12, 13.
„ *crispa*, Id. 1846, For. Foss. Vien., p. 125, pl. vi. figs. 9–14.
„ *flexuosa*, Id. Ibid. p. 127, pl. vi. figs. 15, 16.
„ *crispa*, Williamson, 1849, Trans. Micr. Soc. Lond., vol. ii. p. 159, pl. xxviii.
„ *strigilata*, Schultze, 1854, Organ. Polythal., p. 64, pl. iv.
„ *spinulosa*, Costa, 1856, Atti dell' Accad. Pontan., vol. vii. pl. xix. fig. 14.
„ *ornata*, Id. Ibid. p. 215, pl. xix. fig. 16.
„ *crispa*, Id. Ibid. p. 212, pl. xix. fig. 17.
„ *striolata*, Id. Ibid. pl. xix. fig. 18.
„ *crispa*, Williamson, 1858, Rec. For. Gt. Br., p. 40, pl. iii. figs. 78–80.
„ „ Carpenter, 1862, Introd. Foram., p. 278, pl. xvi. figs. 4–6.
„ „ Parker and Jones, 1865, Phil. Trans., vol. clv. p. 399, pl. xiv. fig. 24; pl. xvii. fig. 61, *a.b.*
„ *costifera*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 47, pl. ii. fig. 26.

The typical *Polystomella crispa* has a thick biconvex test with sharp angular periphery. The septal bands and retral processes are both conspicuously developed, and the umbilical depressions are filled with a deposit of clear shell-substance, convex or slightly umbonate externally, and more or less tubulated; the aperture consists of a V-shaped row of pores at the inner margin of the septal face.

There are few Foraminifera that have been so carefully and accurately studied as the present species, both with respect to the structure of the test and of the soft parts of the animal. Of the memoirs quoted in the foregoing synonymy, the reader interested in the subject may be especially referred to those of Williamson, Schultze, and Carpenter, which leave nothing to be desired in the completeness of their descriptions.

Polystomella crispa is one of the most abundant shallow-water Foraminifera, though not quite so widely diffused as its feebler congener, *Polystomella striatopunctata*. It is found in the North Atlantic, as far north as Disco Bay, Greenland; in the Faröe Channel, on the coast of Great Britain, Denmark, Belgium, France, and Spain, in the Mediterranean and the Adriatic . amongst the West Indies and the Cape de Verde Islands, and southwards to the Falkland Islands. It occurs on the shores of the Indian Ocean, and of the Southern Ocean as far south as Kerguelen Island; on the west coast of

Patagonia and amongst the islands of the South Pacific; and in the North Pacific as far north as Japan. Its recorded bathymetrical range is from the littoral zone to 355 fathoms.

Fossil specimens have been obtained from the Eocene of Paris (Terquem); from the Septaria-clays of Germany (Reuss); from various Miocene deposits of Austria, Hungary, Bavaria, France, and Italy (d'Orbigny, Reuss, Egger, &c.); the Salt-clay of Wieliczka (Reuss); the Pliocene of Italy and the south-east of Spain (Parker and Jones, Seguenza); the Crag of the east of England (Jones, Parker, and Brady); and the Quaternary formations of many parts of Northern and Southern Europe (Sars, Robertson, Wright, &c.).

Polystomella macella, Fichtel and Moll, sp. (Pl. CX. figs. 8, 9, 11 ; and 10 ?).

Nautilus macellus, var. *a*, Fichtel and Moll, 1803, Test. Micr., p. 66, pl. x. figs. *e.–g.*
Polystomella planulata, Lamarck, 1822, Anim. s. Vert., vol. vii. p. 625, No. 3.
„ *lessonii*, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 284, No. 6.
„ „ Id. 1839, Foram. Amér. Mérid., p. 29, pl. iii. figs. 1, 2.
„ *fichteliana*, Id. 1846, For. Foss. Vien., p. 125, pl. vi. figs. 7, 8.
„ *ortenburgensis*, Egger, 1857, Neues Jahrb. für Min., &c., p. 302, pl. xv. figs. 7–9.
„ *macella*, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. v. p. 104, No. 8.
„ *tenuissima*, Karrer, 1864, Novara-Exped., geol. Theil, vol. i. p. 83, pl. xvi. fig. 16.
„ *laminata*, Terquem, 1878, Mém. Soc. géol. France, sér. 3, vol. i., Mém. III. p. 16, pl. i. fig. 8, *a.b.*
„ „ Id. 1882, Ibid. sér. 3, vol. ii., Mém. III. p. 47, pl. ii. fig. 24, *a.b.*

This is a compressed variety of *Polystomella crispa*, with acute or subacute periphery and slightly depressed umbilici. Occasionally the test is somewhat asymmetrical, as depicted in one of the original figures.

It is quite impossible to separate the *Polystomella lessonii* and *Polystomella fichteliana* of d'Orbigny from the present form; and the *Nautilus strigilatus*, var. *a*, of Fichtel and Moll (Test. Micr., p. 49, pl. v. figs. *c.d.e*) only differs from it in having a slight central umbo.

Whether the young shell represented by fig. 10 belongs to the present variety or to the typical *Polystomella crispa* is not very clear. D'Orbigny figures somewhat similar but more convex specimens with peripheral points under the names *Polystomella josephina* and *Polystomella aculeata* (For. Foss. Vien., pl. vi. figs. 25–28).

Polystomella macella is not common in the northern temperate zone, the Mediterranean and the Adriatic being apparently its boreal limit. It has been observed off the Canaries and amongst the West Indies, and occurs also in littoral and shallow-water sands from the Falkland Islands, the Cape of Good Hope, the Mauritius, Madagascar, Kerguelen Island, the shores of Australia and New Zealand, the Fiji Islands, and some of the island groups in the neighbourhood of New Guinea. It is rarely met with at greater depths.

The earliest *Polystomellæ*, geologically speaking, of which we have any knowledge, are specimens of the present form obtained by Dr. Uhlig from the Middle Jura "Ornatenthon" of Russia. It has also been found as a fossil in the Eocene of Paris (Terquem); the Miocene of Vienna (d'Orbigny), of Lower Bavaria (Egger), and of Calabria (Seguenza); the Salt-clay of Wieliczka (Reuss); the Subapennine Tertiaries of Italy (Reuss, Seguenza); the Pliocene of Kar Nicobar (Schwager), and of the Island of Rhodes (Terquem); the Crag of Suffolk (Jones, Parker, and Brady); and the Post-pliocene of Calabria (Seguenza).

Polystomella verriculata, H. B. Brady (Pl. CX. fig. 12, *a.b.*).

Polystomella verriculata, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 66.

Test much compressed, lateral faces flattened, peripheral edge angular or slightly rounded. Septal ridges and retral bars forming a coarse, more or less regular, raised network, covering the surface of the shell. Aperture simple or only slightly notched. Diameter, $\frac{1}{50}$th inch (0·5 mm.).

A variety characterised by the equal limbation of the septal lines and the transverse bars, producing an even but somewhat irregular reticulation of the surface.

Such specimens have been collected at two points on the west coast of Australia, namely, off East Moncœur Island, 38 fathoms; and in Curtis Strait, Queensland.

Polystomella imperatrix, H. B. Brady (Pl. CX. figs. 13–15).

Polystomella imperatrix, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 66.

Test complanate equilateral; peripheral edge subangular, generally subcarinate, furnished with several (three to six) stout radiating spines. Septal lines slightly limbate, marked with pitted depressions; retral bars very numerous, delicate, irregular, sometimes branched. Aperture simple, or only faintly notched. Diameter, $\frac{1}{15}$th inch (1·7 mm.).

This is one of the largest and handsomest of the *Polystomellæ*. It differs from the spinous Miocene variety (*Polystomella regina*, d'Orb., For. Foss. Vien., p. 129, pl. vi. figs. 23, 24) in its complanate contour and larger dimensions—fully-grown specimens having a diameter more than three times that of the fossil form—as well as in the external aspect of septal lines and cross bars. The peripheral spines appear to be developed from the carinal portion of the supplemental skeleton, and are not, like those of some varieties of *Polystomella crispa*, mere radial extensions of the septa.

One or two small examples of *Polystomella imperatrix* were found amongst sand dredged in Port Jackson, 2 to 10 fathoms, the only Challenger Station at which it was collected. But in a small package of similar material from Storm Bay, Tasmania, sent to me many

years ago by the late Dr. Greville of Edinburgh, it was one of the most conspicuous Foraminifera, the specimens being of large size and comparatively plentiful.

Polystomella craticulata, Fichtel and Moll, sp. (Pl. CX. figs. 16, 17).

Nautilus craticulatus, Fichtel and Moll, 1803, Test. Micr., p. 51, pl. v. figs. *h.–k.*
Cellanthus craticulatus, Montfort, 1808, Conchyl. Systém., vol. i. p. 206, 52e genre.
Vorticialis craticulata, Lamarck, 1822, Anim. s. Vert., vol. vii. p. 626, No. 1.
Polystomella craticulata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 284, No. 3.
„ „ Carpenter, 1862, Introd. Foram., p. 279, pl. xvi. figs. 1, 2, &c.
Helicoza craticulata, Moebius, 1880, Foram. von Mauritius, p. 103.

Polystomella craticulata exemplifies to the fullest extent the typical features of the genus. The external characters of the test and its complicated internal structure have been very fully investigated by Carpenter (*loc. cit.*). Moebius, also, more recently has published a brief account of the species, separating it generically from the other *Polystomellæ*, on the ground of certain differences in the distribution of the interseptal canals, a course for which there appears no adequate reason, inasmuch as throughout the genus the canal system is a very variable feature, both in its nature and degree of development. The position to which the organism has been assigned by Carpenter and by Parker and Jones best expresses its natural relationship. It has been characterised by the latter authors as that form of *Polystomella* in which the "canal system, the retral processes of the chambers, the septal bridges, and the apertural bars are all fully developed." Carpenter states that specimens sometimes exceed $\frac{1}{6}$th inch (4·2 mm.) in diameter. I have not myself met with anything so large, but shells of half that size are not uncommon.

Polystomella craticulata inhabits the shallow water of tropical and subtropical seas. Its area of distribution extends from the Levant southwards to the shores of Australia. It has been dredged in the Gulf of Suez, 15 to 30 fathoms; in the Red Sea; off the Mauritius; on the Australian coral-reefs; at ten Challenger Stations amongst the islands of the South Pacific, the depths ranging from 3 to 28 fathoms; in the Chinese Sea; in Hong Kong Harbour, 7 fathoms; and off the Sandwich Islands, 40 fathoms.

It is not known as a fossil species.

Sub-family 3. **Nummulitinæ.**

Amphistegina, d'Orbigny.

Amphistegina, d'Orbigny [1826], Bronn, Reuss, Williamson, Ehrenberg, Carpenter, Parker and Jones, Karrer, Pourtales, Kaufmann, Moebius, Brady.
Heterostegina, Nonionina, Ehrenberg [1855].
Hemistegina, Kaufmann, 1867.

The genus *Amphistegina* was placed by d'Orbigny in his Family Entomostègues, which was characterised by "chambers divided into many cavities by partitions or by

little tubes," and embraced genera as diverse as *Amphistegina*, *Heterostegina*, *Orbiculina*, *Alveolina*, and *Fabularia*. Our knowledge of the true structure and affinities of the type is mainly due to the researches of Williamson, Parker and Jones, and Carpenter.

Normally the test has the form of a lenticular disk, more convex on one side than the other, and consists of an inequilateral turbinoid spire, of which each convolution completely or almost completely encloses its predecessor. The chambers are equitant; the alar prolongations on the superior side are simple, and do not differ very materially from those of a Nummulite; but on the inferior side they are each divided into two portions by a deep constriction, and the secondary lobes thus formed are directed backward and radially, and are so intercalated as to give the appearance externally of an independent whorl of chambers. The aperture is on the inferior side of the final chamber, and resembles that of *Rotalia* in form and position. The surface of the test in the neighbourhood of the aperture is generally rough or granulose. Occasionally the septal lines are beaded or otherwise limbate, and less frequently the surface of the chambers has also a granular exogenous ornament; but as a rule the shell is smooth, except near the orifice on the inferior side. The walls are thick and laminated, and traversed transversely by closely-set tubuli; but the septa are single and there is no canal system.

In the living condition *Amphistegina* is essentially a tropical genus, notwithstanding the fact that it is occasionally met with as far north as Bermuda and the Canary Islands, the former of which is considerably outside the tropical line. Its home is amongst the shallow-water sands of warm seas, and under favourable local conditions it sometimes exists in extraordinary profusion. Occasionally, however, it extends into much deeper areas. With the exception of a minute and somewhat obscure variety, which has been found in the Carboniferous rocks of the west of England, the geological range of the genus is not known to reach beyond the Tertiary epoch; but it has been recognised in strata of almost every period from the Nummulitic formations to the present time.

Amphistegina lessonii, d'Orbigny (Pl. CXI. figs. 1–7).

Compressed lenticular form, figs. 1–4.

Amphistegina lessonii (pars), d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 304, No. 3, pl. xvii. figs. 1–4.

,, *vulgaris*, Id. Ibid. p. 305, No. 8;—Modèle, No. 40.

,, *gibbosa*, Id. 1839, Foram. Cuba, p. 120, pl. viii. figs. 1–3.

,, *hauerina*, Id. 1846, For. Foss. Vien., p. 207, pl. xii. figs. 3–5.

,, *vulgaris*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 25, pl. iii. fig. 91.

,, *nucleata*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mém. III. p. 123, pl. xiii. fig. 1, *a.b.*

Thicker variety, often more inequilateral, figs. 5, 6.

Amphistegina lessonii (pars), d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 304, No. 3;—Modèle, No. 98.

Amphistegina gibbosa, Williamson, 1851, Trans. Micr. Soc. Lond., ser. 1, vol. iii. p. 110, pl. xvii. figs. 1, 2.
„ *lessoni*, Parker, Jones, and Brady, 1865, Ann. and Mag. Nat. Hist., ser. 3, vol. xvi. p. 34, pl. iii. fig. 92.
„ *semicostata*, Kaufmann, 1867, Geol. Beschreib. des Pilatus, p. 149, pl. viii. fig. 18.
„ *lessonii*, Moebius, 1880, Foram. von Mauritius, p. 99, pl. x. figs. 10–14; pl. xi. figs. 1–3.
„ *parisiensis*, Terquem, 1882, Mém. Soc. géol. France, sér. 3, vol. ii. Mem. III. p. 124, pl. xiii. fig. 3, *a.b.*

Thick forms, still more inequilateral, sometimes dome-shaped, fig. 7.

Amphistegina mamillata, d'Orbigny, 1846, For. Foss. Vien., p. 208, pl. xii. figs. 6–8.
„ *rugosa*, Id. Ibid. p. 209, pl. xii. figs. 9–11.
Hemistegina rotula, Kaufmann, 1867, Geol. Beschreib. des Pilatus, p. 150, pl. viii. fig. 19.

It is impossible to separate, even by varietal characters, the various forms of *Amphistegina* represented by the drawings Pl. CXI. figs. 1–7.

The typical aspect of *Amphistegina lessonii* is that represented by d'Orbigny in the plates accompanying the "Tableau Méthodique," and well rendered in fig. 3 of our illustrations. D'Orbigny's Model of the same species (No. 98) portrays a much thicker shell with fewer segments, resembling our fig. 5. The Model, No. 40, named *Amphistegina vulgaris*, is founded upon a more outspread and less regularly constructed specimen, something like our fig. 2, but thicker just at the centre.

Owing to the peculiar form and disposition of the segments, the test of *Amphistegina* is almost necessarily more or less inequilateral. The superior face is nearly always more convex than the inferior, but the degree of asymmetry differs in different individuals, and specimens like fig. 7, in which the superior side is highly convex and the inferior nearly flat, are by no means unfrequent. Such forms constitute the *Amphistegina mamillata* of d'Orbigny, and the *Hemistegina rotula* of Kaufmann.

Wherever *Amphisteginæ* are abundant, and at the shallow-water margins of warm seas they sometimes form the principal constituent of the bottom-sand, all these variations of the typical structure are met with, together with every intermediate condition; and in such profusion as to make it impossible to conceive that the differences between the extremes of the series are anything more than individual peculiarities.

Within certain limits as to depth, *Amphistegina lessonii* is generally distributed over the tropical portions of the Atlantic, Indian, and Pacific Oceans. In the Atlantic it reaches northward as far as Bermuda and Teneriffe, and in the Red Sea to the Gulf of Suez; but, with these exceptions, there is no record of its occurrence outside the tropical zone. It is commonest on bottoms of less than 30 fathoms depth, but is found with some frequency down to 300 or 400 fathoms, below which it is rare. The occurrence of specimens in deeper water has been noted at two Stations in the North Atlantic, 1070 and 1750 fathoms respectively; at one in the South Atlantic, south-east of Pernambuco, 675 fathoms; and at one in the South Pacific, off Tahiti, 620 fathoms.

Fossil specimens corresponding with the forms under notice have been observed in the Eocene deposits of the Paris Basin (Terquem), and in the Upper Eocene of the Swiss Alps (Kaufmann); and they abound in the Miocene and Pliocene strata of Austria, the south of France, the south-east of Spain, Italy, Malta, Costa Rica, Jamaica, San Domingo, Trinidad, Maryland, Virginia, South Carolina, Alabama, Australia, and New Zealand.

Operculina, d'Orbigny.

Nautilus, pars, Gronovius [1781], Schroeter, Gmelin.
Lenticulites, pars, Defrance [1822], Basterot.
Operculina, d'Orbigny [1826], Bronn, Michelotti, Reuss, Leymerie, Cornuel, Rütimeyer, d'Archiac and Haime, Carter, Parker and Jones, Carpenter, Brady, M. Sars, Kaufmann, Hantken, &c.
Amphistegina, pars, d'Orbigny [1826], Reuss.
Nonionina, pars, Williamson [1852], Fischer.
Nummulina, pars, Parker and Jones [1865].

The test of the typical *Operculina* is a thin complanate disk, composed of three or four broad convolutions, symmetrically arranged, and equally visible on both faces. The central portion of the disk is usually somewhat thicker than the outer whorls, and not unfrequently almost umbonate; the earlier convolutions are more or less embracing, the later whorls evolute. The segments are usually very numerous, of gradually increasing size, and typically very short in the direction of growth as compared with their width radially; they are for the most part produced on a uniform plan, but near the finish are often irregular, both as to shape and size (Pl. CXII. figs. 3, 4, and 6). The exterior is sometimes smooth; but more frequently either the sutures, or the surface of the chambers, or both, are ornamented with exogenous granules, papillæ, or tubercles, which as a rule are more strongly developed near the centre than on the later whorls; and in the small, northern variety of the genus, the septal lines and periphery are distinctly limbate. The general aperture is a straight or slightly curved fissure at the inner margin of the final segment, close to the periphery of the previous convolution; but the test has frequently also a number of secondary orifices, in the form of small circular pores on the face of the terminal segment. The septa are double, and the skeleton is furnished with a system of canals, the general features of which are analogous to that of *Nummulites*.

Excepting the genus *Nummulites*, there is probably no foraminiferal type that has been the subject of so large an amount of careful investigation as *Operculina*,[1] and a very complete exposition of what is known of its structure and organisation is given in the Introduction to the Study of the Foraminifera.

[1] *See* Williamson, 1852, *Trans. Micr. Soc. Lond.* (1850), ser. 1, vol. iii. p. 105 [*Nonionina.*] Carter, 1852, *Ann. and Mag. Nat. Hist.*, ser. 2, vol. x. p. 161. Carpenter, 1859, *Phil. Trans.* (1858), p. 12;—1862, Introd. Foram., p. 161.

The larger and more characteristic varieties of *Operculina* are abundant in the tropical and sub-tropical seas of the eastern hemisphere, generally at depths of less than 30 fathoms, but also from time to time in deeper water. The smaller, starved variety inhabits a much wider area, its northern limit extending considerably within the arctic circle, but it is comparatively seldom met with south of the equator.

Cornuel has described a fossil, to all appearance a true *Operculina*,[1] from the Lower Cretaceous (Neocomian) beds of Haute-Marne, and Reuss has figured two forms, evidently *Operculinæ*, from the chalk of Maestricht;[2] but the genus is comparatively rare prior to the commencement of the Tertiary epoch; it is found abundantly, however, in the limestones of the Nummulitic period and in many subsequent formations.

Operculina complanata, Defrance, sp. (Pl. CXII. figs. 3, 4, 5, 8).

"Operculum minimum," Plancus, 1739, Conch. Min., p. 18, pl. iii. fig. 1, A.B.C.
Lenticulites complanata, Defrance, 1822, Dict. Sci. Nat., vol. xxv. p. 453.
„ „ Basterot, 1825, Mém. Géol. Env. Bordeaux, pt. i. p. 18.
Operculina complanata, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 281, pl. xiv. figs. 7–10;—Modèle, No. 80.
„ *ammonea*, Leymerie, 1846, Mém. Soc. géol. France, sér. 2, vol. i. p. 359, pl. xiii. fig. 11, *a.b.*
„ *complanata*, Rütimeyer, 1850, Schweizer Nummuliten-terrain, p. 108, pl. iv. fig. 56.
„ *arabica*, Carter, 1853, Journ. Bombay Br. R. Asiatic Soc., vol. iv. p. 437, pl. xviii.
„ *hardiei*, d'Archiac and Haime, 1853, Descr. Anim. Foss. du groupe nummulitique de l'Inde, p. 346, pl. xxxv. fig. 6, *a.b.c.*
„ *complanata*, Parker and Jones, 1861, Ann. and Mag. Nat. Hist., ser. 3, vol. viii. p. 229.
„ *studeri*, Kaufmann, 1867, Geol. Beschreib. des Pilatus, p. 151, pl. ix. figs. 1, 2.
„ *marginata*, Id. Ibid. p. 152, pl. ix. fig. 4.
„ *complanata*, Moebius, 1880, Foram. von Mauritius, p. 104.

Operculina complanata, var. *granulosa*, Leymerie (Pl. CXII. figs. 6, 7, 9, 10).

Amphistegina fleuriausi, d'Orbigny, 1826, Ann. Sci. Nat., vol. vii. p. 304, No. 7 (name only), *fide* Reuss.
Operculina granulosa, Leymerie, 1846, Mém. Soc. géol. France, sér. 2, vol. i. p. 359, pl. xiii. fig. 12, *a.b.*
Amphistegina fleuriausi, Reuss, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 308, pl. i. figs. 10–12.
Operculina irregularis, Reuss, 1864, Denkschr. d. k. Akad. Wiss. Wien, vol. xxiii. p. 10, pl. i. figs. 17, 18.
„ *granulata*, Gümbel, 1868, Abhandl. d. k. bayer. Akad. d. Wiss., II. Cl., vol. x. p. 663. pl. ii. fig. 111, *a.b.*

[1] *Operculina angularis*, Cornuel, 1848, *Mém. Soc. géol. France*, sér. 2, vol. iii. Mém. III. p. 256, pl. ii. figs. 20–22.

[2] *Operculina cretacea*, Reuss, 1861, Sitzungsb. d. k. Ak. Wiss. Wien, vol. xliv. p. 309, pl. ii. fig. 1; and the so-called *Amphistegina fleuriausi*.

The first available illustrations of this species (*Operculina complanata*), namely, the figures given by d'Orbigny with the "Tableau Méthodique," and his Model, No. 80, represent a shell about a quarter of an inch in diameter, of the thin complanate form, umbonate at the centre, and with smooth exterior; composed of about three rapidly widening convolutions, the segments of which are extremely numerous and much curved. These, therefore, may be regarded as the typical characters of the test.

In a subsequent description of the genus *Operculina* by the same author,[1] it is stated that the spire is non-embracing; but this is by no means correct, for even in the present species, which often presents an almost completely evolute appearance, the earlier convolutions are always more or less embracing, and sometimes the alar extensions of the margins of the segments are sufficient to create a very marked thickening of the central portions of the test. The number of segments in each circuit of the spire differs considerably in different individuals, and has been recognised by some authors as a basis of "specific" grouping.

The condition of the exterior of the test with reference to superficial ornament is also a point of extreme variability. In any large collection of specimens there are always a number that are smooth externally like the d'Orbignian type (Pl. CXII. figs. 3, 4); but commonly by far the larger proportion of the shells present a surface-decoration of raised granules or tubercles. These are sometimes minute, and scattered over the surface of the segments (fig. 10), sometimes in rows along the septal lines, forming a sort of sutural limbation (figs. 6, 7), and sometimes of larger size, and developed chiefly near the centre of the shell on both faces (fig. 9). More rarely the sutures are marked by bright spots of clear shell-substance, which appear like punctations, but are in reality level with the surface, neither elevated nor depressed.

It has been the custom to distinguish the granulose forms specifically from those without surface-markings. It may possibly be convenient to preserve some distinction, but it can only be an artificial one; for the smooth, the partially ornamented, the granulate, and the more strongly papillate varieties form collectively a single continuous series, which it is impossible to divide, except by comparative characters of no real zoological value.

The list of synonyms is probably far from complete, but the drawings of specimens referred to the present genus by palæontological writers are in many cases too small and ill-defined to be identified with any certainty.

Operculina complanata and its granulose modifications are abundant in the Red Sea and in the tropical and subtropical regions of the North and South Pacific, at depths ranging from the littoral zone to 30 or 40 fathoms; and less common down to 420 fathoms, which is the greatest depth at which they have been observed. I can find no record of their occurrence in any part of the Atlantic.

They occur in the Maestricht Chalk, and are plentiful in the Nummulitic limestones of Central Europe; they are also occasionally, though not so frequently, met with in later

[1] For. Foss. Vien., p. 117.

formations, such as the Miocene of Dax near Bordeaux, and of Jamaica, and the Crag of Suffolk.

Operculina ammonoides, Gronovius, sp. (Pl. CXII. figs. 1, 2).

Nautilus ammonoides, Gronovius, 1781, Zooph. Gron., p. 282, No. 1220, and p. v.
„ *balthicus*, Schroeter, 1783, Einleitung, vol. i. p. 20, pl. i. fig. 2.
Operculina complanata, Parker and Jones, 1857, Ann. and Mag. Nat. Hist., ser. 2, vol. xix. p. 285, pl. xi. figs. 3, 4.
Nonionina elegans, Williamson, 1858, Rec. For. Gt. Br., p. 35, pl. iii. figs. 74, 75.
Operculina ammonoides, Parker and Jones, 1862, Introd. Foram., Appendix, p. 810.
Nummulina perforata, var. (*Operculina*) *ammonoides*, Parker and Jones, 1865, Phil. Trans., vol. clv. p. 398; pl. xiv. fig. 44; pl. xvii. figs. 62, 63.
Nonionina elegans, Fischer, 1870, Actes Soc. Linn. Bordeaux, vol. xxvii. p. 396, No. 45.

This is a starved variety, the test of which is of comparatively small dimensions, but proportionately thicker than that of typical *Operculina complanata;* and it is further characterised by having strongly limbate sutures. The diameter seldom much exceeds $\frac{1}{45}$th inch (0·56 mm.).

Operculina ammonoides is not uncommon at moderate depths on the shores of Norway, Denmark, Great Britain, and France. It occurs at fourteen "Porcupine" Stations and one Challenger Station in the North Atlantic, at depths of 45 to 1630 fathoms, the most southerly point being off the Canaries. It has also been observed in the Mediterranean, 320 fathoms, and in the Gulf of Suez, 30 fathoms; off the Cape of Good Hope, 150 fathoms; on the coast of Australia, 17 fathoms; at three points south of Papua, 129 to 800 fathoms; off the Philippines, 95 fathoms; in Hong Kong Harbour, 7 fathoms; and south of Japan, 345 fathoms.

It was one of the Foraminifera obtained by the late Prof. M. Sars from the Post-tertiary beds of Norway, and it is mentioned doubtfully by Seguenza amongst the Pliocene fossils of Calabria.

Heterostegina, d'Orbigny.

Heterostegina, d'Orbigny [1826], Bronn, Reuss, Rütimeyer, Carpenter, Jones and Parker, Carter, Karrer, Kaufmann, Gümbel, Hantken, Brady, Moebius, Seguenza, &c.

The test of *Heterostegina* bears a general analogy to that of *Operculina*. It has the same external contour, and attains like dimensions; and the chambers though differing in certain points are arranged on a similar plan. The primary distinction between the two genera rests upon the fact that whilst the chambers of *Operculina* are simple and entire, those of *Heterostegina* are subdivided by transverse septa into chamberlets. In other words, the mutual relationship of *Operculina* and *Heterostegina* is precisely that which exists between *Peneroplis* and *Orbiculina*, amongst the porcellanous types.

The subdivision of the chambers, however, gives rise to a well-marked difference in the

nature of the aperture, which in *Operculina* consists of a transverse arched fissure at the inner margin of the terminal segment. In *Heterostegina*, on the other hand, the chamberlets of which each chamber is composed have no direct communication with each other, but each chamberlet has an orifice on the outer septal plane; and the row of pores so formed on the face of the final chamber constitutes the general aperture. The canal system resembles that of *Operculina*.

The genus *Heterostegina* inhabits the tropical portions of the Atlantic, Pacific, and Indian Oceans, whilst in the Red Sea it is found as far north as the Gulf of Suez. Its bathymetrical range extends from the littoral zone to a depth of about 600 fathoms. Fossil representatives of the genus occur in Tertiary deposits of almost every age from the Eocene forwards.

Heterostegina depressa, d'Orbigny (Pl. CXII. figs. 14–20).

Heterostegina depressa, d'Orbigny, 1826, Ann. Sci Nat., vol. vii. p. 305, pl. xvii. figs. 5–7;—Modèle, No. 99.
„ *antillarum*, Id. 1839, Foram. Cuba, p. 121, pl. vii. figs. 24, 25.
„ *helvetica*, Kaufmann, 1867, Geol. Beschreib. des Pilatus, p. 153, pl. ix. figs. 6–10.

The Challenger collections have furnished a smaller number of specimens of *Heterostegina* than might have been expected, and their study has added but little to our knowledge of the type. Whether the living representatives of the genus are all referrible to a single species is a question which still remains undetermined. The immature shells present themselves under two apparently very distinct forms, in one of which (figs. 17, 18) the test is compressed and explanate, and the chambers subdivided from the earliest stages; whilst the contour of the other (figs. 19, 20) is biconvex, the convolutions are embracing, and the subdivision of the chambers only commences after one or two convolutions have been formed.

The points in which the adult shells exhibit the greatest amount of variability are—the degree of convexity of the two faces of the test; the greater or less rapidity of the widening of the spire; the development and thickening of the marginal cord; and the greater or less regularity, as well as the amount of external limbation, of the primary and secondary septal lines. Specimens, to all appearance fully grown, vary considerably also in dimensions, and occasionally attain a diameter of half an inch (12·6 mm.) or even more.

Heterostegina depressa has been taken amongst the Cape de Verde Islands, in shore-pools, and at a depth of 11 fathoms; amongst the West Indies; in the South Atlantic, off Pernambuco, 350 fathoms; in the Red Sea, 30 fathoms; on the shores of the Seychelle Islands, Madagascar, and Ceylon; at eleven Stations amongst the islands of the South Pacific, 6 fathoms to 620 fathoms; in the Chinese Sea; and on the coral-reefs of the Sandwich Islands, 40 fathoms.

The claims of the numerous Tertiary *Heterosteginæ* to the specific positions accorded to them by palæontologists, are in almost every case problematical. But without entering into this question, it may be broadly stated, that fossil specimens, identical in all important characters with the recent species, occur as far back as the limestones of the Eocene period.

Nummulites, Lamarck.

Helicites, Guettard [1770], Burtin, Defrance, Blainville.
Nautilus, pars, Forskål [1775], Fichtel and Moll.
Camerina, Bruguière [1792], Bosc, Cuvier.
Phacites, Blumenbach [1799].
Nummulites, Lamarck [1801], Roissy, Defrance, Blainville, Caillaud, Boubée, Ehrenberg, Deshayes, Reuss, Joly and Leymerie, d'Archiac and Haime, Bellardi, Gemmellaro, Carter, Verbeek, Hantken, de la Harpe, Jones, &c.
Discolithes, pars, Fortis [1802].
Lenticulites, pars, Lamarck [1804], Schlotheim, Defrance, Blainville, Bronn, d'Archiac, Rütimeyer.
Numulites, *Lycophris*, *Rotalites*, *Egeon*, Montfort [1808].
Nummularia, Parkinson [1811], Sowerby, Rütimeyer.
Lenticulina, pars, Lamarck [1822], Defrance, Blainville, Reuss.
Nummulina, d'Orbigny [1826], Bronn, Michelotti, Carpenter, Schafhäutl, Rütimeyer, Rouault, Savi and Meneghini, Carter, Costa, Williamson, Jones and Parker, Bornemann, Karrer, Kaufmann, Brady, Terquem, &c.
Amphistegina, pars, Reuss [1855], Carpenter.

The genus *Nummulites* exemplifies the highest type of structure attained by the perforate calcareous Foraminifera. It is, however, a genus of which our knowledge is derived almost entirely from fossil specimens, and its still living representatives, which are limited to one or two inconspicuous forms, afford no sufficient standpoint for a general survey of its characters or history. Of recent years the study of Nummulites and their immediate allies, at any rate so far as affects their comparative morphology and systematic grouping, has been chiefly conducted by specialists, who have had peculiar facilities for obtaining the fossil forms, which exist in enormous numbers in the rocks of the earlier portion of the Tertiary epoch. The literature of the genus is probably more extensive than that of any other group of Protozoa of similar zoological importance; and amongst the authors to whose labours we owe our present accurate acquaintance with the various phases of its history, the names of Joly and Leymerie, d'Archiac and Haime, Williamson, Carpenter, Carter, Jones and Parker, von Hantken, and de la Harpe, are the most prominent. The chief desiderata still remaining are the judicious reduction of the number of so-called species, and the simplification of the nomenclature of the group.

The typical *Nummulite* has the form of a biconvex disk, the two sides of which are equal or nearly so, formed of a number of convolutions, each completely enclosing that

preceding it. The segments are very numerous and V-shaped or embracing. In the larger and more characteristic forms the final convolution becomes gradually more and more contracted at the peripheral margin, until eventually it ceases to be distinguishable, completely closing in the shell. The aperture is a simple arched or V-shaped slit at the inner margin of the final segment. The canal system is highly developed, and forms an important feature of the genus, resembling in the distribution of its parts that of *Operculina* and *Cycloclypeus*.

It is exceedingly difficult, perhaps impossible, to separate the genera *Operculina* and *Nummulites* by any well or strongly defined characters, indeed the former is regarded by Parker and Jones as only a subgeneric modification of the latter type.

With certain authors the explanate varieties of *Nummulites*, that is to say, those in which the outline of the successive convolutions is visible externally owing to the tenuity of the lateral flaps of the chambers, constitute a distinct genus or subgenus, for which the d'Orbignian term *Assilina* is employed.

The genus *Nummulites* is subdivided by d'Archiac and Haime[1] into six "groups," based upon the condition of the surface of the test and the form of the alar extensions of the chambers, namely:—1. *Læves* aut *Sublæves;* 2. *Reticulatæ;* 3. *Subreticulatæ;* 4. *Punctulatæ;* 5. *Plicatæ* vel *Striatæ;* 6. *Explanatæ.* The same classification is followed by Hantken and Madarász.[2] Parker and Jones regard the "granulate" and "explanate" sections as needless, and divide the series into three catagories:—1. *Radiatæ;* 2. *Sinuatæ;* 3. *Reticulatæ.*[3] The latest arrangement is that proposed by de la Harpe, who accepts *Assilina* as a distinct genus, and separates *Nummulites* into two primary groups—(A), Non-reticulate; and (B), Reticulate; each of which is divided into "Granulate" and "Non-granulate" species.[4]

As already stated, living examples of the genus are comparatively scarce. Furthermore, it is difficult in the present state of our knowledge to speak with certainty as to the area of distribution of the recent forms, inasmuch as some of the specimens which have been obtained from dredged sands are, there can be little doubt, derived from Tertiary deposits. Minute but well-characterised Nummulites have been found in the fossil condition at intervals as far back as the limestones of the Carboniferous period; though it was not until the commencement of the Tertiary epoch that any extensive development of the genus took place. The limestones of the Eocene period, which form an important constituent of the mountain-ranges of Central Europe, Central and Southern Asia, and Northern Africa, are largely composed of Nummulitic shells; and, though the genus is less prominent in the Oligocene and subsequent formations, it is present to a greater or less extent at almost every stage of the Tertiary system.

[1] Descr. des anim. foss. du groupe nummulitique de l'Inde, 1853, p. 72.
[2] Katalog d. auf d. Wiener Weltausstellung im Jahre, 1873, ausgestellten Nummuliten.
[3] *Ann. and Mag. Nat. Hist.* 1861, ser. 3, vol. viii. p. 230.
[4] Étude des Nummulites de la Suisse, 1ière partie, 1881, p. 62.

Nummulites cumingii, Carpenter (Pl. CXII. figs. 11–13 ; woodcut, fig. 22).

Amphistegina cumingii, Carpenter, 1859, Phil. Trans., p. 32, pl. v. figs. 13–17.
Nummulina radiata, Id. 1862, Introd. Foram., p. 275.

The drawings (Pl. CXII. figs. 11–13) represent average specimens of a Foraminifer originally figured by Carpenter under the name *Amphistegina cumingii*, but subsequently assigned by him to the genus *Nummulina* or *Nummulites*. On the whole I am inclined to agree in this latter determination, notwithstanding the fact that in any large collection of specimens there are invariably a certain number in which the segments of the final convolution spread out radially, so as to impart an *Operculina*-like aspect to the shell. Two examples with this peculiarity are figured by Carpenter (*op. cit.*, pl. v. figs. 16, 17).

Setting aside these exceptional wild-growing forms, the segmentation of the test presents tolerably uniform characters, which have been accurately rendered by Mr. Hollick in the accompanying woodcut (fig. 22). The horizontal sections of about half a dozen specimens exhibit practically identical features.

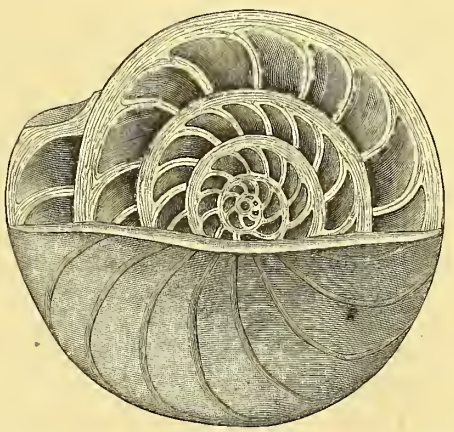

Fig. 22.—*Nummulites cumingii*, Carpenter. Specimen laid open to show the segmentation. Magnified 20 diameters.

A comparison of this drawing with the published figures of the better known fossil species suggests the close affinity of the recent form to *Nummulites variolaria*, Sowerby, and *Nummulites boucheri*, de la Harpe. Compared with *Nummulites variolaria*, the recent shell has only about half the number of convolutions; compared, on the other hand, with *Nummulites boucheri*, the walls and septa are thicker, the spire more regular, and the septal lines more sinuate. This view of the relationship of the recent organism is in general accordance with the opinions arrived at by von Hantken and Rupert Jones.

Nummulites cumingii inhabits the shallower waters of tropical and subtropical latitudes, but it is by no means a common Foraminifer. The following are the localities at which it has been observed:—Gulf of Suez, 10, 15, 20 fathoms; Australian coral-reefs, 17 fathoms; off Fiji Islands, 12 fathoms; Nares Harbour, Admiralty Islands, two Stations, 16 to 25 fathoms; Chinese Sea; and off Philippine Islands.

Sub-family 4. Cycloclypeinæ.

Cycloclypeus, Carpenter.

Cycloclypeus, Carpenter [1856], Carter, Martin, Brady.

The genus *Cycloclypeus* was instituted by Carpenter for the reception of certain discoidal Foraminifera of very large dimensions "dredged by Sir Edward Belcher from a considerable depth of water off the coast of Borneo." Since the publication of the original memoir containing the account of these recent specimens,[1] the structure and affinities of the genus have been further elucidated by the researches of Carter[2] and Martin,[3] upon a number of fossil species. Unfortunately the Challenger collections afford but little material bearing upon the subject. A few examples of a small but very interesting variety, however, have been met with in one of the dredgings, which may be best introduced by a brief indication of the prominent characters of the genus.

The test of *Cycloclypeus* is a circular disk, either regularly biconvex, or umbonate at the centre, with a thin, sharp, peripheral edge. It is composed of concentric annuli, the boundaries of which, as well as those of the constituent chambers, are to a greater or less extent visible externally, being marked, especially near the margin, either by raised bands or by lines of clear shell-substance. The centre of the disk on both sides is often studded with raised beads or tubercles. The general aperture takes the form of a row of marginal pores. The texture of the shell of recent specimens is conspicuously hyaline and finely porous.

Examined by means of sections, the test is found to be composed of three distinct portions, a central disk formed of a layer of chambers arranged in concentric zones, and two lateral plates of compact shell-substance, one on either side, enclosing it more or less completely.

The chambers of the successive annuli of the central disk alternate in position more or less regularly, like those of an Orbitolite. The adjacent chambers of the same annulus do not communicate directly with each other, but each chamber communicates with two chambers of the preceding and two of the succeeding zone. The proportionate length and breadth of the chambers vary in different species and even in different specimens of the same species.

The shelly plates which enclose the median disk above and below are variously developed, but always thickest at the centre. They sometimes attain twice or three times the thickness of the central layer, and in such cases the test assumes the form of a

[1] *Phil. Trans.*, 1856, p. 555. See also Introd. Foram., 1862, p. 292.

[2] *Ann. and Mag. Nat. Hist.*, ser. 3, vol. viii. pp. 332, 461.

[3] Untersuchungen über die Organisation von Cycloclypeus, Carp. und Orbitoides, d'Orb., von Dr. K. Martin, *Niederländisches Archiv für Zoologie*, vol. v. pp. 185–204, pls. xiii., xiv.

biconvex lens, the thickness of which at the middle is equal to one-third of its diameter (*Cycloclypeus neglectus*, Martin); whilst in other instances, like the little species about to be described, the lateral deposit is almost confined to a small area near the centre. Structurally the lateral plates are composed of a succession of superimposed lamellæ, and, except the columns terminating in the external tubercles, which are solid, they are traversed vertically by fine, closely set, parallel tubuli.

The septal walls of the chambers of the central plane are always double, and the entire shelly skeleton is furnished with a complicated system of canals which need not here be minutely described.

Our knowledge of the distribution of the genus as a recent type of Foraminifera is limited to one or two localities in the Eastern Archipelago. Fossil representatives have been obtained by Carter from the early Tertiary limestones of the south-east coast of Arabia, and by Martin from rocks of similar age in Java.

Cycloclypeus guembelianus, H. B. Brady (Pl. CXI. fig. 8, *a.b.*).

Cycloclypeus guembelianus, Brady, 1881, Quart. Journ. Micr. Sci., vol. xxi., N. S., p. 66.

Test discoidal, outline nearly circular; biconvex or subumbonate; the central portion of both faces considerably thickened, the outer zones gradually thinning towards the periphery, which presents a sharp edge; composed of comparatively few annuli. Segments approximately square; when otherwise, the radial diameter usually shorter than the peripheral. Both the annular and radial sutures marked externally by slightly raised lines, the surface of the test being otherwise smooth. Diameter, $\frac{1}{16}$th inch (1·5 mm.).

Two or three tolerably complete specimens of this interesting form have been met with. Notwithstanding their minute dimensions in comparison with the only other recent species hitherto obtained, they are to all appearance fully grown. Apart from the size, their distinctive features appear to be the shape of the chambers, and the relatively slight development of the lateral shelly plates.

Carpenter describes the "typical form of the chambers" as "a parallelogram whose sides are to each other as $1\frac{1}{2}$ to 1, or as 2 or even 3 to 1, the longest side lying in the direction of the radius of the disk." The chambers of the present variety are nearly equilateral, when otherwise, the radial diameter is the shorter of the two. The lateral layers of shell-substance are so little developed that the septation is visible nearly to the centre of the test, and there is an entire absence of the superficial tubercles which form a common feature of the larger species.

I have suggested in a previous paper[1] that the type specimens of *Cycloclypeus* in the

[1] *Quart. Journ. Micr. Sci.*, vol. xxi., N. S., p. 67.

British Museum, upon which Carpenter's description of the genus is based, should be distinguished by the specific name *Cycloclypeus carpenteri*. Some of these specimens are almost unique amongst discoidal Foraminifera in point of size, presenting a diameter of $2\frac{1}{2}$ inches (63 mm.). The smaller species now described has been named after Prof. Gümbel of Munich, whose researches upon the closely allied genus *Orbitoides* are well known to Rhizopodists.

The specimens of *Cycloclypeus guembelianus* were dredged off Kandavu, Fiji Islands, at a depth of 210 fathoms.

Sub-family 5. (?) Eozoöninæ.

The much debated question of the origin and structure of Eozoön lies outside the scope of the present Report. It may however be stated that according to the views of Dawson, Carpenter, Rupert Jones, and others, *Eozoön canadense*, the type of the genus instituted by the first-named author, is a fossil Foraminifer, found in sessile tufts or patches of considerable size; formed of chambers arranged at first in thin layers more or less regularly superimposed, but subsequently irregularly combined and acervuline; the portions representing the calcareous skeleton traversed by long branching canals of peculiar form and disposition.

On the other hand it is maintained by King and Rowney, Carter, Moebius, and those who follow them that the structures referred to are of purely mineral origin, and require no organic hypothesis for their explanation.

DISTRIBUTION TABLES.

TABLE I.—COMPARATIVE VIEW OF THE FORAMINIFERA OF VARIOUS MARINE DEPOSITS.

The following Table affords a means of comparison of the general aspects of the Foraminiferal fauna of the more important oceanic deposits met with during the Challenger cruise. The names employed for the deposits are those made use of by Messrs. Murray and Renard in their researches on the chemical and physical characters of the sea-bottom. Some of them, such as Globigerina Ooze, Pteropod Ooze, Red Clay, and Diatom Ooze, have already been explained (p. 79); of the others, which have been more recently introduced, definitions are given below. The fauna of Grey Ooze or Grey Mud is practically identical with that of Globigerina Ooze, and Radiolaria Ooze contains as a rule the same species of Foraminifera as Red Clay; these, therefore, have been omitted from the Table.

Green Sand.—A deposit found near continental land, owes its green colour to grains of glauconite, isolated or united into concretions. The Foraminifera and other organisms are frequently filled with glauconitic substance, and casts of these remain after treatment with acid. Mineral particles derived from the neighbouring continents are also present.

Green Mud.—A deposit found under similar conditions to Green Sand, but in deeper water, contains similar mineral particles, but with a larger proportion of argillaceous and other amorphous matter.

Blue Mud.—The most extensive deposit now forming around continents and continental islands, and in enclosed and partially enclosed seas. There is generally a thin layer of a reddish hue on the surface. The blue colour is due to organic matter in a state of decomposition. The principal portion is composed of mineral particles derived from the disintegration of the neighbouring lands.

Red Mud.—A deposit met with by the Challenger only off the coast of Brazil; differing from Blue Mud in the presence of a quantity of ochreous matter which is brought down by the rivers and deposited along the coast.

Volcanic Mud.—Mud dredged at no great distance from land in volcanic regions, consisting to a great extent of volcanic dust and minerals of eruptive origin. In the Pacific such deposits contain much coral débris, and the fauna is similar to that of Coral Mud.

Coral Mud.—A white calcareous sandy mud consisting mainly of coral detritus.

Globigerina Ooze.

A. Station 98. North Atlantic, off the African coast, about the latitude of Sierra Leone; depth 1750 fathoms.

B. Station 338. South Atlantic, mid-ocean; depth 1990 fathoms.

C. Station 271. Pacific, nearly under the equator, mid-ocean; depth 2425 fathoms.

The Rhizopodal fauna of Globigerina Ooze is further illustrated by Table II.

Pteropod Ooze.

D. Station 24. Off Culebra Island, Danish West Indies; depth 390 fathoms.

E. Station 337. South Atlantic, mid-ocean; depth 1240 fathoms.

The former locality is near land, and the dredged material has furnished no less than 177 species of Foraminifera; the latter is in mid-ocean and has yielded but sixteen species, the whole of which, with one doubtful exception, are pelagic forms.

Red Clay.

F. Station 9. North Atlantic, mid-ocean; depth 3150 fathoms.

G. Station 253. North Pacific, mid-ocean; depth 3125 fathoms.

H. Station 286. South Pacific, mid-ocean; depth 2335 fathoms.

The Rhizopodal fauna of the Red Clay is further illustrated by Table III.

Diatom Ooze.

I. Station 157. Southern Ocean, mid-ocean; depth 1950 fathoms.

GREEN SAND.

J. Station 142. Off the Cape of Good Hope; depth 150 fathoms.
The fauna at this Station presents various points of similarity to that of many of the "Porcupine" dredgings from somewhat higher latitudes in the North Atlantic.

GREEN MUD.

K. Station 164A. South Pacific; off Sydney, Australia; depth 410 fathoms. Almost the whole of the Foraminifera infiltrated with glauconite.

L. Station 232. North Pacific; south of Japan ("Hyalonema Ground"); depth 345 fathoms.

BLUE MUD.

M. Station 153. Antarctic Ice-barrier; depth 1675 fathoms.

N. Station 299. South Pacific, between Juan Fernandez and Valparaiso; depth 2160 fathoms.

RED MUD.

O. Station 120. South Atlantic, off Pernambuco; depth, 675 fathoms.

VOLCANIC MUD.

P. Station 260A. North Pacific, Honoruru coral-reefs; depth, 40 fathoms.

Q. Station 279A. South Pacific, off Tahiti; depth, 420 fathoms.

CORAL MUD.

R. Station 172. Off Tongatabu, Friendly Islands; depth, 18 fathoms.

TABLE I.—Comparative View of the Foraminifera of Various Marine Deposits.

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
		Globigerina Ooze. Station 98; depth 1750 fath.	Globigerina Ooze. Station 338; depth 1990 fath.	Globigerina Ooze. Station 271; depth 2425 fath.	Pteropod Ooze. Station 24; depth 390 fath.	Pteropod Ooze. Station 337; depth 1240 fath.	Red Clay. Station 9; depth 3150 fath.	Red Clay. Station 253; depth 3125 fath.	Red Clay. Station 286; depth 2335 fath.	Diatom Ooze. Station 157; depth 1950 fath.	Green Sand. Station 142; depth 150 fath.	Green Mud. Station 164 A; depth 410 fath.	Green Mud. Station 232; depth 345 fath.	Blue Mud. Station 153; depth 1675 fath.	Blue Mud. Station 299; depth 2160 fath.	Red Mud. Station 120; depth 675 fath.	Volcanic Mud. Station 260 A; 40 fath.	Volcanic Mud. Station 279 A; depth 420 fath.	Coral Mud. Station 172; depth 18 fath.	
1	*Nubecularia divaricata*, Br.,																		×	1
2	,, *inflata*, Br.,																×	×	×	2
3	,, *lucifuga*, Defr.,																		×	3
4	,, *tibia*, J. & P.,				×															4
5	*Biloculina bulloides*, d'Orb.,										×									5
6	,, *comata*, Br.,				×							×								6
7	,, *depressa*, d'Orb.,	×	×		×			×	×			×	×			×				7
8	,, var. *serrata*, Br.,	×																		8
9	,, *elongata*, d'Orb.,				×															9
10	,, *irregularis*, d'Orb.,														×					10
11	,, *lævis* (Defr.),				×															11
12	,, *ringens* (Lamk.),				×							×				×		×		12
13	,, var. *denticulata*, Br.,																×		×	13
14	,, *sphæra*, d'Orb.,				×											×				14
15	*Spiroloculina acutimargo*, Br.,															×				15
16	,, *convexiuscula*, Br.,																×			16
17	,, *crenata*, Kar,				×												×			17
18	,, *excavata*, d'Orb.,																×	×		18
19	,, *fragilissima*, Br.,																	×		19
20	,, *grata*, Terq.,																×	×	×	20
21	,, *limbata*, d'Orb.,				×							×				×				21
22	,, *nitida*, d'Orb.,																×	×		22
23	,, *planulata* (Lamk.),				×												×			23
24	,, *robusta*, Br.,				×															24
25	,, *tenuis* (Czjzek),		×									×				×				25
26	*Miliolina agglutinans* (d'Orb.),										×	×								26
27	,, *alveoliniformis*, Br.,																×	×	×	27
28	,, *amygdaloides*, Br.,												×							28
29	,, *auberiana* (d'Orb.),				×															29
30	,, *bicornis* (W. & J.),																×			30
31	,, *bucculenta*, Br.,				×															31
32	,, *cuvieriana* (d'Orb.),																×			32
33	,, *ferussacii* (d'Orb.),																×		×	33
34	,, *insignis*, Br.,				×													×		34
35	,, *labiosa* (d'Orb.),							×									×			35
36	,, *linnæana* (d'Orb.),																×		×	36
37	,, *macilenta*, Br.,																×			37
38	,, *oblonga* (Montag.),			×	×							×				×	×	×	×	38
39	,, *parkeri*, Br.,																×	×	×	39
40	,, *pygmæa* (Rss.),												×					×		40
41	,, *reticulata* (d'Orb.),				×												×		×	41
42	,, *secans* (d'Orb.),																×			42
43	,, *seminulum* (Linn.),		×					×				×				×	×		×	43

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1990 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 300 fath.	Pteropod Ooze St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2335 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
44	*Miliolina subrotunda* (Montag.), .																×			44
45	,, *tricarinata* (d'Orb.), . .				×							×				×		×	×	45
46	,, *trigonula* (Lamk.), . .				×												×	×	×	46
47	,, *undosa* (Kar.), . . .																×			47
48	*Articulina conico-articulata* (Batsch.)				×												×	×		48
49	,, *sagra*, d'Orb., ...				×												×		×	49
50	,, *sulcata* (Rss.), ...																×			50
51	*Vertebralina insignis*, Br., . . .				×														×	51
52	,, *striata*, d'Orb., . .																×	×		52
53	*Ophthalmidium inconstans*, Br., .				×							×				×		×		53
54	,, *tumidulum*, Br., .				×															54
55	*Hauerina ornatissima* (Kar), . .																	×	×	55
56	*Planispirina celata* (Costa), . .				×								×			×				56
57	,, *sigmoidea*, Br., . .				×											×				57
58	*Cornuspira foliacea* (Phil.), . .				×															58
59	,, *involvens*, Rss., . . .				×											×		×		59
60	*Peneroplis lævigatus*, Kar., . . .				×															60
61	,, *pertusus* (Forsk.), . .																×		×	61
62	*Orbiculina adunca* (F. & M.), . .				×															62
63	*Orbitolites complanata* (Lamk.), .																×		×	63
64	,, var. *laciniata*, Br., .																		×	64
65	,, *duplex*, Carp., ...																		×	65
66	,, *marginalis* (Lamk.), . .				×												×		×	66
67	*Alveolina boscii* (Defr.), ...																×		×	67
68	,, *melo* (F. &. M.), . . .																×			68
69	*Keramosphæra murrayi*, Br., . .									×										69
70	*Astrorhiza arenaria*, Norm., . .										×									70
71	*Pelosina cylindrica*, Br., ...	×												×						71
72	*Technitella legumen*, Norm., . . .											×								72
73	*Psammosphæra fusca*, Schulze, . .								×		×			×		×				73
74	*Hyperammina elongata*, Br., . .	×		×	×			×				×				×				74
75	,, *friabilis*, Br., . .				×															75
76	,, *ramosa*, Br., . . .	×			×		×	×	×			×			×	×				76
77	,, *subnodosa*, Br., . .				×															77
78	,, *vagans*, Br., . . .		×		×				×							×				78
79	*Rhabdammina abyssorum*, M. Sars,	×										×								79
80	,, *discreta*, Br., . . .														×					80
81	,, *linearis*, Br., . . .				×											×				81
82	*Aschemonella catenata* (Norm.), .	×			×															82
83	,, *ramuliformis*, Br., .							×												83
84	*Rhizammina algæformis*, Br., . .			×											×					84
85	,, *indivisa*, Br., . . .										×									85
86	*Sagenella frondescens*, Br., . . .																		×	86
87	*Reophax adunca*, Br., ...															×				87
88	,, *dentaliniformis*, Br., . .							×									×			88

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1990 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 390 fath.	Pteropod Ooze. St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2335 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
89	*Reophax difflugiformis*, Br.,			×								×			×					89
90	,, *distans*, Br.,	×					×	×						×	×	×				90
91	,, *nodulosa*, Br.,	×										×								91
92	,, *pilulifera*, Br.,	×																		92
93	,, *scorpiurus*, Montf.,	×	×	×	×			×	×	×			×			×	×		×	93
94	*Haplophragmium agglutinans* (d'Orb.),							×							×					94
95	,, *anceps*, Br.,				×										×					95
96	,, *calcareum*, Br.,				×							×				×				96
97	,, *canariense* (d'Orb.)							×			×				×		×			97
98	,, *emaciatum*, Br.,				×						×									98
99	,, *foliaceum*, Br.,												×							99
100	,, *globigeriniforme* (P. & J.),	×		×	×			×	×			×			×	×				100
101	,, *glomeratum*, Br.,			×											×					101
102	,, *latidorsatum* (Born.),	×		×	×			×	×					×		×				102
103	,, *nanum*, Br.,							×												103
104	,, *rotulatum*, Br.,						×													104
105	,, *scitulum*, Br.,				×															105
106	*Placopsilina bulla*, Br.,														×					106
107	,, *cenomana* (d'Orb.),																		×	107
108	*Haplostiche soldanii* (J. & P.),				×															108
109	*Thurammina papillata*, Br.,	×	×	×	×			×								×				109
110	*Hormosina carpenteri*, Br.,	×			×															110
111	,, *globulifera*, Br.,	×			×										×					111
112	,, *normani*, Br.,			×																112
113	,, *ovicula*, Br.,			×						×										113
114	*Ammodiscus charoides* (J. & P.),	×		×																114
115	,, *gordialis* (J. & P.),			×	×			×				×			×	×				115
116	,, *incertus* (d'Orb.),				×			×								×				116
117	*Trochammina conglobata*, Br.,															×				117
118	,, *coronata*, Br.,				×											×				118
119	,, *galeata*, Br.,				×															119
120	,, *lituiformis*, Br.,				×											×				120
121	,, *pauciloculata*, Br.,			×											×	×				121
122	,, *proteus*, Kar.,				×							×				×				122
123	,, *ringens*, Br.,	×																	×	123
124	,, *squamata*, J. & P.,				×															124
125	,, *trullissata*, Br.,			×	×				×											125
126	*Webbina clavata*, J. & P.,	×			×							×				×				126
127	*Cyclammina cancellata*, Br.,		×		×											×				127
128	,, *orbicularis*, Br.,													×						128
129	,, *pusilla*, Br.,													×						129
130	*Textularia agglutinans*, d'Orb.,				×			×			×	×						×		130
131	,, var. *porrecta*, Br.,											×							×	131

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1990 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 390 fath.	Pteropod Ooze. St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2335 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
132	*Textularia aspera*, Br., ...				×											×				132
133	,, *barrettii*, J. & P., . .				×															133
134	,, *concava* (Kar.), . . .				×														×	134
135	,, *conica*, d'Orb., . . .																	×	×	135
136	,, *folium*, P. & J., . . .																×			136
137	,, *gramen*, d'Orb., . . .												×			×	×		×	137
138	,, *inconspicua*, Br., . .												×							138
139	,, *luculenta*, Br., . . .				×											×				139
140	,, *quadrilatera*, Schw., .											×	×					×		140
141	,, *rugosa* (Rss.), ...																		×	141
142	,, *sagittula*, Defr., . . .										×									142
143	,, *siphonifera*, Br., . .																×		×	143
144	,, *trochus*, d'Orb., . . .				×															144
145	,, *turris*, d'Orb., . . .				×															145
146	*Verneuilina propinqua*, Br., . . .	×																		146
147	,, *pygmæa* (Egger), . .		×		×			×	×	×						×				147
148	,, *spinulosa*, Rss., . . .				×												×		×	148
149	,, *triquetra* (Münst.), . .				×															149
150	*Chrysalidina dimorpha*, Br., . .																×			150
151	*Bigenerina capreolus* (d'Orb.), . .				×											×				151
152	,, *pennatula* (Batsch), . .				×															152
153	,, *robusta*, Br., ...				×															153
154	*Pavonina flabelliformis*, d'Orb., .				×												×			154
155	*Gaudryina filiformis*, Berth., . .				×													×		155
156	,, *pupoides*, d'Orb., . .	×		×	×				×			×						×		156
157	,, var. *chilostoma*, Rss.,																	×		157
158	,, *rugosa*, d'Orb., . . .										×					×				158
159	,, *scabra*, Br., ...				×															159
160	,, *subrotundata*, Schw., .				×															160
161	*Valvulina fusca* (Will.), ...				×							×								161
162	*Clavulina angularis*, d'Orb., . . .																		×	162
163	,, *communis*, d'Orb., . .				×					×		×	×	×						163
164	,, *parisiensis*, d'Orb., . .				×			×												164
165	*Bulimina aculeata*, d'Orb., . . .				×						×	×	×			×				165
166	,, *affinis*, d'Orb., ...							×												166
167	,, *buchiana*, d'Orb., . . .				×						×	×				×				167
168	,, *contraria* (Rss.), . . .										·	×	×							168
169	,, *elegans*, var. *exilis*, Br., .												×							169
170	,, *elegantissima*, d'Orb., .											×				×				170
171	,, *inflata*, Seg., ...			×	×								×					×		171
172	,, *marginata*, d'Orb., . .										×		×			×		×		172
173	,, *pupoides*, d'Orb., . . .											×								173
174	,, *pyrula*, d'Orb., ...				×						×	×	×					×		174
175	,, *subcylindrica*, Br., . .															×				175
176	,, *subteres*, Br., ...				×							×				×				176

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1990 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 390 fath.	Pteropod Ooze. St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2335 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
177	*Bulimina subornata*, Br.,												×							177
178	*Virgulina schreibersiana*, Czjz.,		×	×				×										×		178
179	,, *squamosa*, d'Orb.,	×			×			×					×					×		179
180	,, *subsquamosa*, Egger,												×					×		180
181	*Bolivina beyrichi*, Rss.,											×	×							181
182	,, *karreriana*, Br.,												×			×		×		182
183	,, *limbata*, Br.,																×		×	183
184	,, *hantkeniana*, Br.,																	×		184
185	,, *nobilis*, Hantk.,																	×		185
186	,, *porrecta*, Br.,				×													×		186
187	,, *punctata*, d'Orb.,				×								×			×		×		187
188	,, *reticulata*, Hantk.,																	×		188
189	,, *robusta*, Br.,										×	×	×			×				189
190	,, *textilarioides*, Rss.,																×			190
191	*Cassidulina bradyi*, Norm.,											×	×							191
192	,, *crassa*, d'Orb.,	×								×		×	×			×	×	×		192
193	,, *lævigata*, d'Orb.,										×	×	×	×				×		193
194	,, *subglobosa*, Br.,				×					×		×				×				194
195	*Ehrenbergina hystrix*, Br.,			×																195
196	,, *serrata*, Rss.,			×								×								196
197	*Chilostomella ovoidea*, Rss.,				×			×				×	×					×		197
198	*Allomorphina trigona*, Rss.,												×							198
199	*Lagena acuta* (Rss.),			×								×				×				199
200	,, *acuticosta*, Rss.,			×																200
201	,, *aspera*, Rss.,															×				201
202	,, *desmophora*, Ry. J.,															×				202
203	,, *distoma*, P. & J.,												×							203
204	,, *fimbriata*, Br.,			×																204
205	,, *formosa*, Schw.,								×						×					205
206	,, *globosa* (Montag.),		×									×					×			206
207	,, *gracilis*, Will.,		×	×																207
208	,, *gracillima* (Seg.),												×					×		208
209	,, *hexagona* (Will.),			×								×					×			209
210	,, *hispida*, Rss.,	×			×								×							210
211	,, *interrupta*, Will.,				×															211
212	,, *lævigata* (Rss.),		×	×				×	×	×										212
213	,, *lævis* (Montag.),		×		×				×				×			×				213
214	,, *lagenoides* (Will.),		×									×				×				214
215	,, var. *tenuistriata*, Br.,		×																	215
216	,, *longispina*, Br.,	×																		216
217	,, *lucida* (Will.),		×																	217
218	,, *marginata* (W. & B.),	×		×	×			×	×			×	×			×	×			218
219	,, var. *semimarginata* (Rss.),	×																		219
220	,, *orbignyana* (Seg.),			×	×			×	×			×	×			×				220
221	,, *plumigera*, Br.,			×																221

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1900 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 390 fath.	Pteropod Ooze. St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2335 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
222	*Lagena quadricostulata*, Rss., . .											×								222
223	,, *seminiformis*, Schw., . .	×	×																	223
224	,, *semistriata*, Will., . . .							×												224
225	,, *squamosa* (Montag.), . . .		×		×							×								225
226	,, *striata* (d'Orb.), ...		×										×				×			226
227	,, *striatopunctata*, P. & J., .				×							×				×				227
228	,, *sulcata* (W. & J.), . . .			×	×							×	×							228
229	*Nodosaria* (Gl.) *æqualis*, Rss., . .				×										×					229
230	,, *calomorpha*, Rss., . .		×																	230
231	,, *comata* (Batsch), . . .				×															231
232	,, (D.) *communis*, d'Orb., .			×	×				×	×		×				×		×		232
233	,, *consobrina* var. *emaciata*, Rss., ...				×						×	×								233
234	,, *costulata*, Rss., . . .				×															234
235	,, *farcimen*, Sold., . . .				×											×				235
236	,, (D.) *filiformis*, d'Orb., .				×															236
237	,, *hispida*, d'Orb., . . .				×							×								237
238	,, (Gl.) *lævigata*, d'Orb., .				×							×								238
239	,, (D.) *mucronata* (Neugeb.)	×		×									×							239
240	,, (D.) *obliqua* (Linn.), .	×			×						×	×								240
241	,, *proxima*, Silv., . . .																×			241
242	,, *pyrula*, d'Orb., . . .												×					×		242
243	,, *radicula* (Linn.), . . .										×									243
244	,, *raphanus* (Linn.), . .				×															244
245	,, *roemeri* (Neugeb.), . .				×															245
246	,, *scalaris* (Batsch), . .										×		×							246
247	,, *soluta*, Rss., ...				×							×				×				247
248	,, *subcanaliculata* (Neugeb.)																	×		248
249	,, *vertebralis* (Batsch), .				×															249
250	*Lingulina carinata*, d'Orb., . . .				×											×	×			250
251	,, var. *seminuda*, Hantk.				×															251
252	*Frondicularia alata*, d'Orb., . . .				×															252
253	,, *inæqualis*, Costa, .										×									253
254	,, *robusta*, Br., . . .																×			254
255	*Rhabdogonium tricarinatum* (d'Orb.)				×							×				×				255
256	*Marginulina costata* (Batsch), . .				×															256
257	,, *glabra*, d'Orb., . .	×											×							257
258	*Vaginulina legumen* var. *arquata*, Br.				×															258
259	,, *linearis* (Montag.), . .				×															259
260	,, *spinigera*, Br., . . .											×				×				260
261	*Cristellaria aculeata*, d'Orb., . .				×															261
262	,, *acutauricularis* (F. & M.)				×						×									262
263	,, *articulata*, Rss., . . .				×															263
264	,, *calcar* (Linn.), . . .				×															264
265	,, *convergens*, Bornem., .				×							×						×		265
266	,, *crepidula* (F. & M.), . .				×												×	×		266

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1990 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 390 fath.	Pteropod Ooze. St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2335 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
267	*Cristellaria cultrata* (Montf.),				×											×				267
268	,, *gibba*, d'Orb.,				×							×								268
269	,, *italica* (Defr.),				×							×								269
270	,, *latifrons*, Br.,				×															270
271	,, *obtusata*, Rss.,		×								×									271
272	,, *orbicularis* (d'Orb.),											×						×		272
273	,, *papillosa* (F. & M.),				×															273
274	,, *reniformis*, d'Orb.,				×															274
275	,, *rotulata* (Lamk.),		×		×						×	×	×							275
276	,, *schloenbachi*, Rss.,				×															276
277	,, *variabilis*, Rss.,				×							×	×			×				277
278	,, *vortex* (F. & M.),																	×		278
279	*Amphicoryne falx* (J. & P.),										×									279
280	*Polymorphina angusta*, Egger,		×																	280
281	,, *compressa*, d'Orb.,				×															281
282	,, *lactea* (W. & J.),		×		×															282
283	,, *lanceolata*, Rss.,			×																283
284	*Polymorphina longicollis*, Br.,		×	×																284
285	,, *ovata*, d'Orb.,				×															285
286	,, *regina*, B. P. & J.,																×			286
287	*Uvigerina angulosa*, Will.,										×			×						287
288	,, *asperula*, Czjz.,	×			×				×			×	×			×	×			288
289	,, var. *ampullacea*, Br.,				×							×				×		×		289
290	,, *canariensis*, d'Orb.,										×									290
291	,, *pygmæa*, d'Orb.,				×						×	×	×			×	×			291
292	*Sagrina annulata*, Br.,																×			292
293	,, *bifrons*, Br.,												×							293
294	,, *columellaris*, Br.,											×						×		294
295	,, *dimorpha*, P. & J.,				×													×		295
296	,, *nodosa*, P. & J.,										×									296
297	,, *raphanus*, P. & J.,												×				×	×	×	297
298	,, *virgula*, Br.,															×				298
299	*Globigerina æquilateralis*, Br.,		×	×	×	×					×					×	×	×		299
300	,, *bulloides*, d'Orb.,	×	×	×	×	×	×	×	×	×	×	×	×		×	×	×	×	×	300
301	,, *conglobata*, Br.,	×	×		×	×			×		×	×				×	×		×	301
302	,, *digitata*, Br.,		×													×				302
303	,, *dubia*, Egger,	×	×	×							×		×			×				303
304	,, *dutertrei*, d'Orb.,									×				×						304
305	,, *helicina*, d'Orb.,		×									×				×				305
306	,, *inflata*, d'Orb.,		×			×	×	×		×	×	×	×			×				306
307	,, *pachyderma* (Ehr.),						?	×	×											307
308	,, *rubra*, d'Orb.,	×	×			×	×					×				×	×			308
309	,, *sacculifera*, Br.,	×	×	×	×	×					×	×	×			×				309
310	*Orbulina porosa*, Terq.,				×															310
311	,, *universa*, d'Orb.,	×	×		×	×	×	×			×	×	×		×	×	×			311

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1990 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 390 fath.	Pteropod Ooze. St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2935 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
312	*Hastigerina pelagica* (d'Orb.), . .		×	×		×										×		×		312
313	*Pullenia obliquiloculata*, P. & J., .	×	×	×	×							×	×			×				313
314	,, *quinqueloba*, Rss., . . .											×				×				314
315	,, *sphæroides* (d'Orb.), . .			×						×		×	×			×				315
316	*Sphæroidina bulloides*, d'Orb., . .	×			×						×	×	×			×		×		316
317	,, *dehiscens*, P. & J., . .	×	×	×	×	×					×	×	×		×	×		×		317
318	*Candeina nitida*, d'Orb., ...		×			×										×				318
319	*Spirillina decorata*, Br., ...				×											×				319
320	,, *inæqualis*, Br., ...																×		×	320
321	,, *limbata*, Br., ...															×				321
322	,, *tuberculata*, Br., . . .																×			322
323	,, *vivipara*, Ehr., ...				×												×		×	323
324	*Patellina corrugata*, Will., . . .																	×		324
325	*Cymbalopora poeyi* (d'Orb.), . . .				×											×	×	×	×	325
326	,, *tabellæformis*, Br., . .																×			326
327	,, (*Tr.*) *bulloides* (d'Orb.),																×			327
328	*Discorbina bertheloti* (d'Orb.), . .														×					328
329	,, *concinna*, Br., ...																	×		329
330	,, *orbicularis* (Terq.), . .				×														×	330
331	,, *patelliformis*, Br., . .																×			331
332	,, *pileolus* (d'Orb.), . . .																		×	332
333	,, *rosacea* (d'Orb.), . . .																×	×	×	333
334	,, *saulcii* (d'Orb.), . . .																	×		334
335	,, *tabernacularis*, Br., . .																×		×	335
336	,, *valvulata* (d'Orb.), . .																		×	336
337	*Planorbulina larvata*, P. & J., . .																×			337
338	*Truncatulina akneriana* (d'Orb.), .															×			×	338
339	,, *culter* (P. & J.), . .															×				339
340	,, *echinata*, Br., . . .																×		×	340
341	,, *haidingerii* (d'Orb.), .		×								×	×						×		341
342	,, *lobatula* (W. & J.), .			×	×				×		×	×	×	×	×	×	×	×	×	342
343	,, *pygmæa*, Hantk., . .			×			×	×	×	×					×					343
344	,, *refulgens* (Montf.), .										×									344
345	,, *reticulata* (Czjz.), . .				×							×								345
346	,, *robertsoniana*, Br., .				×											×				346
347	,, *rostrata*, Br., . . .																		×	347
348	,, *soluta*, Br., ...				×															348
349	,, *tenuimargo*, Br., . .											×								349
350	,, *ungeriana* (d'Orb.), .	×		×	×													×		350
351	,, *variabilis*, d'Orb., .										×						×		×	351
352	,, *wuellerstorfi* (Schw.),	×	×								×	×	×			×				352
353	*Anomalina ariminensis* (d'Orb.), .				×						×									353
354	,, *grosserugosa* (Gümb.), .												×		×	×				354
355	,, *polymorpha*, Costa, . .				×							×								355
356	*Carpenteria monticularis*, Cart., .																×			356

TABLE I.—VARIOUS DEPOSITS—*Continued.*

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
		Globigerina Ooze. St. 98; — 1750 fath.	Globigerina Ooze. St. 338; — 1990 fath.	Globigerina Ooze. St. 271; — 2425 fath.	Pteropod Ooze. St. 24; — 390 fath.	Pteropod Ooze. St. 337; — 1240 fath.	Red Clay. St. 9; — 3150 fath.	Red Clay. St. 253; — 3125 fath.	Red Clay. St. 286; — 2335 fath.	Diatom Ooze. St. 157; — 1950 fath.	Green Sand. St. 142; — 150 fath.	Green Mud. St. 164 A; — 410 fath.	Green Mud. St. 232; — 345 fath.	Blue Mud. St. 153; — 1675 fath.	Blue Mud. St. 299; — 2160 fath.	Red Mud. St. 120; — 675 fath.	Volcanic Mud. St. 260 A; — 40 fath.	Volcanic Mud. St. 279 A; — 420 fath.	Coral Mud. St. 172; — 18 fath.	
357	*Carpenteria proteiformis*, Goës, .				×															357
358	,, *utricularis*, Cart., . .																		×	358
359	*Rupertia stabilis*, Wall., ...										×									359
360	*Pulvinulina auricula* (F. & M.), .				×													×		360
361	,, *canariensis* (d'Orb.), .					×						×	×			×			×	361
362	,, *crassa* (d'Orb.), . . .	×				?	×		×	×		×								362
363	,, *dispansa*, Br., . . .				×															363
364	,, *elegans* (d'Orb.), . .				×											×		×		364
365	,, *exigua*, Br., ...								×											365
366	,, *favus*, Br., ...			×																366
367	,, *hauerii* (d'Orb.), . .											×						×		367
368	,, *lateralis* (Terq.), . .																		×	368
369	,, *menardii* (d'Orb.), .	×	×		×	×	×				×	×	×			×	×			369
370	,, var. *fimbriata*, Br.,	×			×											×				370
371	,, *micheliniana* (d'Orb.),		×		×	×	×				×	×	×		×	×				371
372	,, *oblonga* (Will.), . .										×									372
373	,, *partschiana* (d'Orb.), .	×		×							×	×	×							373
374	,, *patagonica* (d'Orb.), .		×			×														374
375	,, *pauperata*, P. & J., .	×	×		×											×				375
376	,, *punctulata* (d'Orb.), .				×															376
377	,, *repanda* (F. & M.), .																×			377
378	,, *tumida*, Br., ...	×	×	×	×	×							×			×				378
379	,, *umbonata*, Rss., . .							×					×			×				379
380	*Rotalia beccarii* (Linn.), ...								×								×			380
381	,, *orbicularis*, d'Orb., . . .										×	×	×			×		×		381
382	,, *soldanii*, d'Orb., ...	×	×	×	×				×	×	×							×		382
383	*Calcarina hispida*, Br., ...																		×	383
384	*Gypsina inhærens* (Schultze), . .																		×	384
385	,, *vesicularis* (P. & J.), . .				×												×		×	385
386	*Polytrema miniaceum* (Linn.), . .				×												×		×	386
387	*Nonionina pompilioides* (F. & M.),			×						×										387
388	,, *scapha* (F. & M.), . . .				×								×				×			388
389	,, *turgida* (Will.), . . .				×								×						×	389
390	,, *umbilicatula* (Montag.),		×	×	×			×	×			×								390
391	*Polystomella craticulata* (F. & M.),																×		×	391
392	,, *crispa* (Linn.), . . .												×						×	392
393	,, *macella* (F. & M.), . .										×									393
394	,, *striatopunctata* (F. & M.)				×												×			394
395	*Amphistegina lessonii*, d'Orb., . .	×			×											×	×	×	×	395
396	*Operculina ammonoides* (Gron.), .										×		×							396
397	,, *complanata* (Defr.), . .																×	×	×	397
398	,, var. *granulosa* (Ley.),																×		×	398
399	*Heterostegina depressa*, d'Orb., . .																×	×	×	399

TABLE II.—THE FORAMINIFERA OF GLOBIGERINA OOZE.

The annexed Table is intended to illustrate the nature and extent of the Foraminiferal fauna of Globigerina Ooze. The Stations have been selected with a view to as complete a representation as possible of the various conditions which may be supposed to influence the distribution of animal life, such as latitude, depth of water, distance from land, and the like.

Under all circumstances the bulk of a Globigerina Ooze is made up of the shells of the pelagic species of *Globigerina*, *Pulvinulina*, *Sphæroidina*, and *Pullenia;* there are, however, invariably present a large number of non-pelagic forms, some of which are so frequently met with that they may be regarded as normal constituents of the deposit. Of such species there are twenty-four which appear in half or more than half of the sixteen columns of the annexed Table—namely, *Biloculina depressa*, 15; *Rotalia soldanii*, 15; *Nonionina umbilicatula*, 14; *Pulvinulina patagonica*, 13 (possibly pelagic); *Lagena lævigata*, 12; *Truncatulina wuellerstorfi*, 12; *Miliolina seminulum*, 11; *Haplophragmium latidorsatum*, 11; *Verneuilina pygmæa*, 11; *Virgulina schreibersiana*, 10; *Lagena marginata*, 10; *Pullenia sphæroides*, 10; *Miliolina venusta*, 9; *Lagena orbignyana*, 9; *Uvigerina pygmæa*, 9; *Truncatulina lobatula*, 9; *Pulvinulina elegans* (and *partschiana*), 9; *Gaudryina pupoides*, 8; *Lagena globosa*, 8; *Nodosaria* (*D*) *communis*, 8; *Uvigerina asperula*, 8; *Sphæroidina bulloides*, 8; *Truncatulina ungeriana*, 8; and *Pulvinulina pauperata*, 8. There are many others, as may be seen from the Table, which are common over large areas, though not so generally diffused as the foregoing.

A.	North Atlantic.	"Porcupine" Station 20. West of the north-west point of Ireland; depth 1443 fathoms.
B.	,,	Station 70. Mid-ocean, west of the Azores; depth 1675 fathoms.
C.	,,	Station 78. Near the Azores; depth 1000 fathoms.
D.	South Atlantic.	Station 111. Mid-ocean, tropical (equatorial); depth, 2475 fathoms.
E.	,,	Station 346. Mid-ocean, tropical; depth, 2350 fathoms.
F.	,,	Station 332. Mid-ocean, temperate zone; depth, 2200 fathoms.

G. South Atlantic.	Station 335. Mid-ocean, temperate zone; depth, 1425 fathoms.
H. Southern Ocean.	Station 144. Near Prince Edward Island; depth, 1570 fathoms.
I. „	Station 146. Between Prince Edward Island and Kerguelen Island; depth, 1375 fathoms.
J. North Pacific.	Station 214. Tropical; south-east of the Philippine Islands; depth, 500 fathoms.
K. „	Station 224. Tropical, north of the Admiralty Islands; depth, 1850 fathoms.
L. South Pacific.	Station 218. Equatorial, near the coast of Papua; depth, 1070 fathoms.
M. „	Station 271. Equatorial, mid-ocean; depth, 2425 fathoms.
N. „	Station 280. Tropical, mid-ocean; depth, 1940 fathoms.
O. „	Station 300. Temperate zone, near Juan Fernandez; depth, 1375 fathoms.
P. „	Station 302. Temperate zone, somewhat further south; depth, 1450 fathoms.

TABLE II.—The Foraminifera of Globigerina Ooze.

		North Atlantic ("Porcupine"). St. 20; — 1443 fath. A	North Atlantic. St. 70; — 1675 fath. B	North Atlantic. St. 78; — 1000 fath. C	South Atlantic. St. 111; — 2475 fath. D	South Atlantic. St. 346; — 2350 fath. E	South Atlantic. St. 352; — 2200 fath. F	South Atlantic. St. 335; — 1425 fath. G	Southern Ocean. St. 144; — 1570 fath. H	Southern Ocean. St. 146; — 1375 fath. I	North Pacific. St. 214; — 500 fath. J	North Pacific. St. 224; — 1850 fath. K	South Pacific. St. 218; — 1070 fath. L	South Pacific. St. 271; — 2425 fath. M	South Pacific. St. 280; — 1940 fath. N	South Pacific. St. 300; — 1375 fath. O	South Pacific. St. 302; — 1450 fath. P	
1	*Biloculina bulloides*, d'Orb.,			×			×											1
2	,, *comata*, Br.,												×					2
3	,, *depressa*, d'Orb.,	×	×	×	×	×	×	×	×	×	×	×	×		×	×	×	3
4	,, ,, var. *murrhyna*, Schw.,											×						4
5	,, ,, var. *serrata*, Br.,	×											×					5
6	,, *irregularis*, d'Orb.,												×					6
7	,, *ringens* (Lamk.),	×		×				×								×		7
8	,, *sphæra*, d'Orb.,			×		×							×			×		8
9	*Spiroloculina acutimargo*, Br.,							×										9
10	,, *limbata*, d'Orb.,												×					10
11	,, *tenuis* (Czjz.),				×		×	×	×				×			×	×	11
12	*Miliolina insignis*, Br.,					×												12
13	,, *oblonga* (Montag.),								×				×	×				13
14	,, *secans* (d'Orb.),												×					14
15	,, *seminulum* (Linn.),		×	×	×	×		×	×	×			×		×	×	×	15
16	,, *tricarinata* (d'Orb.),	×						×										16
17	,, *trigonula* (Lamk.),			×														17
18	,, *venusta* (Kar.),		×		×	×	×	×				×	×		×		×	18
19	*Ophthalmidium inconstans*, Br.,			×														19
20	*Planispirina celata* (Costa),	×		×						×			×					20
21	,, *contraria* (d'Orb.),		×													×		21
22	*Astrorhiza angulosa*, Br.,			×														22
23	,, *granulosa*, Br.,			×														23
24	*Pelosina rotundata*, Br.,		×															24
25	*Psammosphæra fusca*, Schulze,		×				×					×						25
26	*Hyperammina elongata*, Br.,						×		×					×		×		26
27	,, *ramosa*, Br.,		×	×			×			×						×		27
28	,, *vagans*, Br.,											×	×					28
29	*Marsipella cylindrica*, Br.,															×		29
30	*Rhabdammina abyssorum*, M. Sars,			×						×			×					30
31	,, *discreta*, Br.,			×									×			×		31
32	*Aschemonella catenata* (Norm.),											×						32
33	*Rhizammina algæformis*, Br.,								×	×				×		×		33
34	*Reophax adunca*, Br.,						×		×							×		34
35	,, *bacillaris*, Br.,												×					35
36	,, *cylindrica*, Br.,								×									36
37	,, *dentaliniformis*, Br.,	×					×		×			×				×		37
38	,, *difflugiformis*, Br.,	×					×	×					×	×		×		38
39	,, *distans*, Br.,								×				×			×		39
40	,, *fusiformis* (Will.),	×																40
41	,, *nodulosa*, Br.,					×						×	×					41
42	,, *pilulifera*, Br.,					×							×					42

TABLE II.—GLOBIGERINA OOZE—*Continued.*

		North Atlantic ("Porcupine"). St. 20; — 1443 fath.	North Atlantic. St. 70; — 1675 fath.	North Atlantic. St. 78; — 1000 fath.	South Atlantic. St. 111; — 2475 fath.	South Atlantic. St. 346; — 2350 fath.	South Atlantic. St. 332; — 2200 fath.	South Atlantic. St. 335; — 1425 fath.	Southern Ocean. St. 144; — 1570 fath.	Southern Ocean. St. 146; — 1375 fath.	North Pacific. St. 214; — 500 fath.	North Pacific. St. 224; — 1850 fath.	South Pacific. St. 218; — 1070 fath.	South Pacific. St. 271; — 2425 fath.	South Pacific. St. 280; — 1940 fath.	South Pacific. St. 300; — 1375 fath.	South Pacific. St. 302; — 1450 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
43	*Reophax scorpiurus*, Montf.,			×			×							×				43
44	*Haplophragmium anceps*, Br.,						×											44
45	,, *agglutinans* (d'Orb.),	×					×						×					45
46	,, *canariense* (d'Orb.),	×						×				×						46
47	,, *foliaceum*, Br.,												×					47
48	,, *fontinense*, Terq.,															×		48
49	,, *globigeriniforme* (P. & J.),	×		×		×	×	×					×	×				49
50	,, *glomeratum*, Br.,					×								×				50
51	,, *latidorsatum* (Born.),	×		×	×		×			×		×	×	×	×	×	×	51
52	,, *nanum*, Br.,					×												52
53	,, *scitulum*, Br.,	×																53
54	,, *tenuimargo*, Br.,												×					54
55	,, *turbinatum*, Br.,					×												55
56	*Thurammina papillata*, Br.,		×	×		×	×		×					×				56
57	*Hormosina carpenteri*, Br.,			×											×			57
58	,, *globulifera*, Br.,					×	×						×			×		58
59	,, *normani*, Br.,													×				59
60	,, *ovicula*, Br.,						×						×	×				60
61	*Ammodiscus charoides* (J. & P.),					×	×		×	×			×	×				61
62	,, *gordialis* (J. & P.),				×								×	×				62
63	,, *incertus* (d'Orb.),					×	×						×					63
64	*Trochammina galeata*, Br.,					×	×					×						64
65	,, *pauciloculata*, Br.,	×										×	×	×		×		65
66	,, *ringens*, Br.,		×			×												66
67	,, *trullissata*, Br.,					×	×		×					×	×			67
68	*Webbina clavata*, J. & P.,								×	×			×			×	×	68
69	*Cyclammina cancellata*, Br.,												×					69
70	*Textularia agglutinans*, d'Orb.,			×												×		70
71	,, ,, var. *porrecta*, Br.,					×												71
72	,, *aspera*, Br.,							×										72
73	,, *concava* (Kar.),				×		×											73
74	,, *quadrilatera*, Schw.,															×		74
75	,, *sagittula*, Defr.,							×					?					75
76	*Verneuilina propinqua*, Br.,			×														76
77	,, *pygmæa* (Egger),	×	×		×	×	×		×	×		×	×		×	×		77
78	*Gaudryina baccata*, Schw.,	×																78
79	,, *pupoides*, d'Orb.,			×		×		×					×	×	×	×	×	79
80	,, ,, var. *chilostoma*, Rss.,							×								×		80
81	,, *siphonella*, Rss.,					×							×					81
82	*Valvulina conica*, P. & J.,															×		82
83	*Clavulina communis*, d'Orb.,						×			×			×			×		83
84	*Bulimina aculeata*, d'Orb.,									×			×					84
85	,, *buchiana*, d'Orb.,		×	×												×	×	85

TABLE II.—GLOBIGERINA OOZE—*Continued.*

		North Atlantic ("Porcupine"). St. 20; — 1443 fath.	North Atlantic. St. 70; — 1675 fath.	North Atlantic. St. 78; — 1000 fath.	South Atlantic. St. 111; — 2475 fath.	South Atlantic. St. 346; — 2350 fath.	South Atlantic. St. 352; — 2200 fath.	South Atlantic. St. 335; — 1425 fath.	Southern Ocean. St. 144; — 1570 fath.	Southern Ocean. St. 146; — 1375 fath.	North Pacific. St. 214; — 500 fath.	North Pacific. St. 224; — 1850 fath.	South Pacific. St. 218; — 1070 fath.	South Pacific. St. 271; — 2425 fath.	South Pacific. St. 280; — 1940 fath.	South Pacific. St. 300; — 1375 fath.	South Pacific. St. 302; — 1450 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
86	*Bulimina contraria* (Rss.),												×					86
87	,, *elegans*, var. *exilis*, Br.,	×																87
88	,, *elongata*, d'Orb.,							×										88
89	,, *inflata*, Seg.,	×											×	×		×		89
90	,, *marginata*, d'Orb.,									×						×		90
91	,, *ovata*, d'Orb.,	×					×											91
92	,, *pupoides*, d'Orb.,															×		92
93	,, *pyrula*, d'Orb.,	×				×	×						×			×		93
94	,, *rostrata*, Br.,							×	×									94
95	*Virgulina schreibersiana*, Czjz.,	×		×	×	×	×	×	×					×		×	×	95
96	,, *squamosa*, d'Orb.,	×																96
97	,, *subdepressa*, Br.,					×	×									×		97
98	,, *texturata*, Br.,					×										×		98
99	*Bolivina amygdalæformis*, Br.,												×					99
100	,, *decussata*, Br.,															×	×	100
101	,, *limbata*, Br.,							×										101
102	,, *punctata*, d'Orb.,			×			×	×	×							×		102
103	,, *reticulata*, Hantk.,							×	×									103
104	*Pleurostomella subnodosa*, Rss.,					×	×											104
105	*Cassidulina bradyi*, Norm.,																×	105
106	,, *crassa*, d'Orb.,					×				×	×				×	×	×	106
107	,, *lævigata*, d'Orb.,								×		×							107
108	,, *subglobosa*, Br.,			×												×	×	108
109	*Ehrenbergina hystrix*, Br.,													×	×			109
110	,, *serrata*, Rss.,					×										×		110
111	*Chilostomella ovoidea*, Rss.,					×							×					111
112	*Lagena acuta* (Rss.),					×	×	×	×			×		×				112
113	,, *acuticosta*, Rss.,													×				113
114	,, *apiculata* (Rss.),												×					114
115	,, *aspera*, Rss.,												×			×		115
116	,, *auriculata*, Br.,					×	×			×		×					×	116
117	,, ,, var. *substriata*, Br.,									×		×						117
118	,, *botelliformis*, Br.,																×	118
119	,, *desmophora*, Ry. J.,					×						×				×		119
120	,, *distoma*, P. & J.,	×																120
121	,, *elongata* (Ehrenb.),												×					121
122	,, *exsculpta*, Br.,							×										122
123	,, *feildeniana*, Br.,						×		×									123
124	,, *fimbriata*, Br.,													×				124
125	,, *formosa*, Schw.,							×				×	×		×	×		125
126	,, ,, var. *comata*, Br.,											×						126
127	,, ,, var. *favosa*, Br.,											×						127
128	,, *globosa* (Montag.),				×	×	×			×		×	×			×	×	128

TABLE II.—GLOBIGERINA OOZE—*Continued.*

		North Atlantic ("Porcupine"). St. 20; — 1443 fath.	North Atlantic. St. 70; — 1675 fath.	North Atlantic. St. 78; — 1000 fath.	South Atlantic. St. 111; — 2475 fath.	South Atlantic. St. 346; — 2350 fath.	South Atlantic. St. 332; — 2200 fath.	South Atlantic. St. 335; — 1425 fath.	Southern Ocean. St. 144; — 1570 fath.	Southern Ocean. St. 146; — 1375 fath.	North Pacific. St. 214; — 500 fath.	North Pacific. St. 224; — 1850 fath.	South Pacific. St. 218; — 1070 fath.	South Pacific. St. 271; — 2425 fath.	South Pacific. St. 280; — 1940 fath.	South Pacific. St. 300; — 1375 fath.	South Pacific. St. 302; — 1450 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
129	*Lagena gracillima* (Seg.),	×					×						×					129
130	,, *gracilis*, Will.,				×	×			×					×				130
131	,, *hexagona* (Will.),								×					×				131
132	,, *hispida*, Rss.,															×		132
133	,, *interrupta*, Will.,												×					133
134	,, *lævigata* (Rss.),	×	×		×	×	×	×	×	×		×	×	×			×	134
135	,, *lævis* (Montag.),				×	×	×	×		×			×			×		135
136	,, *lagenoides* (Will.),						×	×										136
137	,, *longispina*, Br.,						×	×		×			×					137
138	,, *marginata* (W. & B.),			×	×	×	×					×	×	×	×	×	×	138
139	,, *multicosta* (Kar.),					×												139
140	,, *orbignyana* (Seg.),				×	×	×		×			×	×	×		×	×	140
141	,, *plumigera*, Br.,													×				141
142	,, *quadralata*, Br.,						×											142
143	,, *semimarginata*, Rss.,					×	×											143
144	,, *seminiformis*, Schw.,					×		×				×				×	×	144
145	,, *seminuda*, Br.,					×	×									×	×	145
146	,, *semistriata*, Will.,	×		×														146
147	,, *siliqua*, Ry. J.,					×												147
148	,, *squamoso-marginata*, P. & J.,	×																148
149	,, *staphyllearia* (Schw.),					×											×	149
150	,, *stelligera*, Br.,					×			×			×						150
151	,, *striata* (d'Orb.),					×			×				×			×		151
152	,, *striatopunctata*, P. & J.,						×											152
153	,, *sulcata* (W. & J.),				×	×	×		×					×		×	×	153
154	,, *torquata*, Br.,															×		154
155	,, *trigono-ornata*, Br.,												×					155
156	,, *truncata*, Br.,						×											156
157	,, *unguiculata*, Br.,						×											157
158	*Nodosaria calomorpha*, Rss.,						×											158
159	,, (D.) *communis*, d'Orb.,	×			×	×	×	×					×	×		×		159
160	,, (D.) *consobrina*, d'Orb.,															×		160
161	,, *hispida*, d'Orb.,							×										161
162	,, (D.) *inflexa*, Rss.,															×		162
163	,, (Gl.) *lævigata*, d'Orb.,			×						×			×					163
164	,, (D.) *mucronata*, Neug.,	×				×	×		×					×		×	×	164
165	,, (D.) *obliqua* (Linn.),	×								×								165
166	,, *radicula* (Linn.),					×												166
167	,, *raphanus* (Linn.),															×		167
168	,, (D.) *roemeri*, Neug.,											×						168
169	*Marginulina costata* (Batsch),					×												169
170	,, *glabra*, d'Orb.,					×												170
171	*Vaginulina legumen* (Linn.),	×				×		×										171

TABLE II.—GLOBIGERINA OOZE—*Continued.*

		North Atlantic ("Porcupine"). St. 20; — 1443 fath.	North Atlantic. St. 70; — 1675 fath.	North Atlantic. St. 78; — 1000 fath.	South Atlantic. St. 111; — 2475 fath.	South Atlantic. St. 346; — 2350 fath.	South Atlantic. St. 352; — 2200 fath.	South Atlantic. St. 335; — 1425 fath.	Southern Ocean. St. 144; — 1570 fath.	Southern Ocean. St. 146; — 1375 fath.	North Pacific. St. 214; — 500 fath.	North Pacific. St. 224; — 1850 fath.	South Pacific. St. 218; — 1070 fath.	South Pacific. St. 271; — 2425 fath.	South Pacific. St. 280; — 1940 fath.	South Pacific. St. 300; — 1375 fath.	South Pacific. St. 302; — 1450 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
172	*Cristellaria compressa*, d'Orb.,			×														172
173	,, *convergens*, Bornem.,					×						×				×		173
174	,, *crepidula* (F. & M.),					×												174
175	,, *cultrata* (Montf.),			×														175
176	,, *italica*, var. *volpicellii* (Costa),							×										176
177	,, *rotulata* (Lamk.),						×											177
178	,, *tenuis*, Bornem.,					×												178
179	*Polymorphina angusta*, Egger,					×	×	×					×			×		179
180	,, *lanceolata*, Rss.,		×			×				×				×				180
181	,, *longicollis*, Br.,													×		×		181
182	,, *rotundata* (Bornem.),											×						182
183	,, *sororia*, Rss.,																×	183
184	,, ,, var. *cuspidata*, Br.,	×								×								184
185	*Uvigerina aculeata*, d'Orb.,															×		185
186	,, *angulosa*, Will.,	×									×					×		186
187	,, *asperula*, Czjz.,		×			×	×	×					×		×	×	×	187
188	,, *canariensis*, d'Orb.,															×		188
189	,, *interrupta*, Br.,															×		189
190	,, *porrecta*, Br.,											×						190
191	,, *pygmæa*, d'Orb.,	×	×				×	×	×	×					×	×	×	191
192	*Sagrina virgula*, Br.,															×		192
193	*Globigerina æquilateralis*, Br.,		×	×				×			×	×	×	×	×			193
194	,, *bulloides*, d'Orb.,	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	194
195	,, *conglobata*, Br.,		×	×	×	×		×			×	×	×		×			195
196	,, *cretacea*, d'Orb.,					?		?										196
197	,, *digitata*, Br.,															×		197
198	,, *dubia*, Egger,				×				×		×		×	×		×	×	198
199	,, *helicina*, d'Orb.,				×							×				×		199
200	,, *inflata*, d'Orb.,	×	×	×	×	×	×	×	×	×	×					×	×	200
201	,, *pachyderma* (Ehrenb.),	×																201
202	,, *rubra*, d'Orb.,		×	×		×		×					×					202
203	,, *sacculifera*, Br.,				×	×					×	×	×	×	×			203
204	*Orbulina universa*, d'Orb.,	×	×	×		×	×	×	×		×	×	×		×	×	×	204
205	*Hastigerina pelagica* (d'Orb.),		×					×						×				205
206	*Pullenia obliquiloculata*, P. & J.,		×		×	×					×	×	×	×	×			206
207	,, *quinqueloba*, Rss.,	×				×	×		×			×				×		207
208	,, *sphæroides* (d'Orb.),	×			×	×	×	×		×		×		×	×	×		208
209	*Sphæroidina bulloides*, d'Orb.,	×				×	×		×	×		×	×			×		209
210	,, *dehiscens*, P. & J.,		×			×		×			×	×	×	×	×	×		210
211	*Candeina nitida*, d'Orb.,							×			×				×	×		211
212	*Spirillina decorata*, Br.,			×														212
213	,, *limbata*, Br.,							×										213
214	*Truncatulina dutemplei* (d'Orb.),																	214

TABLE II.—GLOBIGERINA OOZE—*Continued.*

		North Atlantic ("Porcupine"). St. 20; — 1443 fath.	North Atlantic. St. 70; — 1675 fath.	North Atlantic. St. 78; — 1000 fath.	South Atlantic. St. 111; — 2475 fath.	South Atlantic. St. 346; — 2350 fath.	South Atlantic. St. 332; — 2200 fath.	South Atlantic. St. 335; — 1425 fath.	Southern Ocean. St. 144; — 1570 fath.	Southern Ocean. St. 146; — 1375 fath.	North Pacific. St. 214; — 500 fath.	North Pacific. St. 224; — 1850 fath.	South Pacific. St. 218; — 1070 fath.	South Pacific. St. 271; — 2425 fath.	South Pacific. St. 280; — 1940 fath.	South Pacific. St. 300; — 1375 fath.	South Pacific. St. 302; — 1450 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
215	*Truncatulina haidingerii* (d'Orb.),								×									215
216	,, *humilis*, Br.,			×														216
217	,, *lobatula*, W. & J.,	×		×	×		×			×	×	×		×		×		217
218	,, *pygmæa*, Hantk.,				×				×			×		×	×		×	218
219	,, *robertsoniana*, Br.,	×																219
220	,, *tenera*, Br.,															×		220
221	,, *ungeriana* (d'Orb.),		×				×	×					×	×	×	×	×	221
222	,, *wuellerstorfi* (Schw.),	×	×	×		×	×	×	×	×		×	×		×		×	222
223	*Anomalina ariminensis* (d'Orb.),						×											223
224	*Rupertia stabilis*, Wall.,															×		224
225	*Pulvinulina canariensis* (d'Orb.),	×	×	×		×	×	×								×	×	225
226	,, *crassa* (d'Orb.),			×	×	×		×		×					×	×		226
227	,, *elegans* (d'Orb.),			×				×		×								227
228	,, *exigua*, Br.,	×			×		×					×					×	228
229	,, *favus*, Br.,											×		×	×	×	×	229
230	,, *menardii* (d'Orb.),	×	×		×	×	×				×	×	×		×	×	×	230
231	,, ,, var. *fimbriata*, Br.,					×												231
232	,, *micheliniana* (d'Orb.),	×	×	×	×	×	×	×	×	×					×	×	×	232
233	,, *partschiana* (d'Orb.),	×	×										×	×	×		×	233
234	,, *patagonica* (d'Orb.),	×	×	×	×	×		×	×	×	×	×			×	×	×	234
235	,, *pauperata*, P. & J.,		×			×		×		×		×	×			×	×	235
236	,, *tumida*, Br.,				×	×		×			×	×	×	×	×			236
237	,, *umbonata*, Rss.,				×					×			×		×	×		237
238	*Rotalia orbicularis*, d'Orb.,	×		×			×	×				×	×			×		238
239	,, *soldanii*, d'Orb.,	×	×	×	×	×	×	×		×	×	×	×	×	×	×	×	239
240	*Polytrema miniaceum* (Linn.),			×														240
241	*Nonionina depressula* (W. & J.),						×											241
242	,, *pompilioides* (F. & M.),	×		×			×		×			×		×	×			242
243	,, *scapha* (F. & M.),															×		243
244	,, *umbilicatala* (Montag.),	×	×		×	×	×		×	×	×	×	×	×	×	×	×	244
245	*Polystomella striatopunctata* (F. & M.),					×												245

TABLE III.—THE FORAMINIFERA OF RED CLAY.

The following Table contains the record of the Foraminifera obtained from fourteen samples of Red Clay dredged in areas far apart, and under various conditions as to latitude and depth of water.

The Foraminiferal fauna they reveal varies from something resembling that of a Globigerina Ooze (A, K, N), to one consisting mainly or almost exclusively of arenaceous species (E, G). But though pelagic forms, *Globigerinæ*, *Pulvinulinæ*, and others, are almost invariably present to a greater or less extent, their shells are relatively few in number, and generally exhibit a worn and corroded appearance. Perhaps the most remarkable fact in connection with the calcareous perforate Foraminifera of these deposits is the great abundance in certain cases (F, L) of minute *Lagenæ*, many of which are endowed with superficial ornament of extraordinary delicacy and beauty. In rare instances Milioline shells are met with, in which the normal calcareous test is replaced by a delicate film of silica.

A.	Station 5.	North Atlantic.	South-west of the Canaries; depth, 2740 fathoms.
B.	Station 9.	,,	Mid-ocean; depth, 3150 fathoms.
C.	Station 160.	Southern Ocean.	South of Australia; depth, 2600 fathoms.
D.	Station 206.	Chinese Sea.	West of the Philippines; depth, 2100 fathoms.
E.	Station 238.	North Pacific.	Mid-ocean; depth, 3950 fathoms.
F.	Station 241.	,,	Mid-ocean; depth, 2300 fathoms.
G.	Station 244.	,,	Mid-ocean; depth, 2900 fathoms.
H.	Station 253.	,,	Mid-ocean; depth, 3125 fathoms.
I.	Station 256.	,,	North of the Sandwich Islands; depth, 2950 fathoms.
J.	Station 265.	,,	South of the Sandwich Islands; depth, 2900 fathoms.

K. Station 179. South Pacific. West of the New Hebrides; depth, 2325 fathoms.

L. Station 276. ,, North of the Society Islands; depth, 2350 fathoms.

M. Station 285. ,, South of the Low Archipelago, mid-ocean; depth, 2375 fathoms.

N. Station 296. ,, South-west of Juan Fernandez; depth, 1825 fathoms.

TABLE III.—The Foraminifera of Red Clay.

		North Atlantic. St. 5; — 2740 fath.	North Atlantic. St. 9; — 3150 fath.	Southern Ocean. St. 160; — 2600 fath.	Chinese Sea. St. 206; — 2100 fath.	North Pacific. St. 238; — 3950 fath.	North Pacific. St. 241; — 2300 fath.	North Pacific. St. 244; — 2900 fath.	North Pacific. St. 253; — 3125 fath.	North Pacific. St. 256; — 2950 fath.	North Pacific. St. 265; — 2900 fath.	South Pacific. St. 179; — 2325 fath.	South Pacific. St. 276; — 2350 fath.	South Pacific. St. 285; — 2375 fath.	South Pacific. St. 296; — 1825 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	*Biloculina bulloides*, d'Orb.,												×			1
2	,, *depressa*, d'Orb.,	×					×	×	×			×	×		×	2
3	,, *elongata*, d'Orb.,														×	3
4	,, *ringens* (Lamk.),	×						×								4
5	*Miliolina amygdaloides*, Br.,	×														5
6	,, *insignis*, Br.,							×								6
7	,, *labiosa* (d'Orb.),				×	×	×	×	×		×					7
8	,, *oblonga* (Montag.),							×					×			8
9	,, *seminulum* (Linn.),							×	×			×	×		×	9
10	,, *venusta* (Karr.),	×													×	10
11	*Spiroloculina planulata* (Lamk.),			×												11
12	,, *tenuis* (Czjzek),			×											×	12
13	*Ophthalmidium tumidulum*, Br.,						×									13
14	*Pelosina cylindrica*, Br.,							×								14
15	*Technitella legumen*, Norm.,												×			15
16	*Psammosphæra fusca*, Schulze,			×										×		16
17	*Sorosphæra confusa*, Br.,							?								17
18	*Jaculella acuta*, Br.,							×								18
19	*Hyperammina elongata*, Br.,								×							19
20	,, *ramosa*, Br.,		×		×		×	×	×	×	×			×	×	20
21	,, *subnodosa*, Br.,						×									21
22	,, *vagans*, Br.,							×			×	×			×	22
23	*Aschemonella catenata* (Norm.),	×						×								23
24	,, *ramuliformis*, Br.,							×	×							24

TABLE III.—RED CLAY—*Continued.*

		North Atlantic. St. 5; — 2740 fath.	North Atlantic. St. 9; — 3150 fath.	Southern Ocean. St. 160; — 2600 fath.	Chinese Sea. St. 206; — 2100 fath.	North Pacific. St. 233; — 3950 fath.	North Pacific. St. 241; — 2300 fath.	North Pacific. St. 244; — 2900 fath.	North Pacific. St. 253; — 3125 fath.	North Pacific. St. 256; — 2950 fath.	North Pacific. St. 265; — 2900 fath.	South Pacific. St. 179; — 2325 fath.	South Pacific. St. 276; — 2350 fath.	South Pacific. St. 285; — 2375 fath.	South Pacific. St. 296; — 1825 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
25	*Rhizammina algæformis*, Br.,							×								25
26	*Reophax adunca*, Br.,			×				×		×						26
27	,, *dentaliniformis*, Br.,			×		×	×		×				×		×	27
28	,, *difflugiformis*, Br.,	×		×		×	×			×			×			28
29	,, *distans*, Br.,			×			×									29
30	,, *membranacea*, Br.,					×										30
31	,, *nodulosa*, Br.,		×				×	×	×	×	×	×				31
32	,, *pilulifera*, Br.,							×								32
33	,, *scorpiurus*, Montf.,	×			×	×			×	×				×		33
34	*Haplophragmium agglutinans* (d'Orb.),	×					×	×	×							34
35	,, *anceps*, Br.,														×	35
36	,, *canariense* (d'Orb.),					×			×							36
37	,, *foliaceum* (Br.),			×												37
38	,, *globigeriniforme* (P. & J.),	×			×	×	×	×	×						×	38
39	,, *glomeratum*, Br.,	×												×		39
40	,, *latidorsatum* (Born.),	×		×	×	×	×	×	×	×	×	×		×	×	40
41	,, *nanum*, Br.,								×							41
42	,, *rotulatum*, Br.,	×	×					×								42
43	,, *scitulum*, Br.,							×								43
44	,, *tenuimargo*, Br.,	×				×										44
45	*Thurammina papillata*, Br.,	×		×					×						×	45
46	*Hormosina globulifera*, Br.,	×					×	×								46
47	,, *normani*, Br.,							×							×	47
48	,, *ovicula*, Br.,			×	×	×	×									48
49	*Ammodiscus gordialis* (J. & P.),	×			×		×	×	×	×	×	×	×		×	49
50	,, *incertus* (d'Orb.),								×			×				50
51	,, *proteus* (Karr.),												×			51
52	,, *shoneanus*, Sidd.,					×										52
53	*Trochammina coronata*, Br.,					?										53
54	,, *galeata*, Br.,	×		×											×	54
55	,, *pauciloculata*, Br.,					×	×									55
56	,, *trullissata*, Br.,	×		×	×	×	×			×			×	×		56
57	*Webbina clavata*, J. & P.,	×														57
58	*Cyclammina cancellata*, Br.,							×								58
59	*Textularia agglutinans*, d'Orb.,						×		×			×	×			59
60	,, *concava* (Karr.),			×												60
61	,, *gramen*, d'Orb.,						×									61
62	*Verneuilina propinqua*, Br.,							×							×	62
63	,, *pygmæa* (Egger),	×		×			×	×	×			×	×	×	×	63
64	,, *spinulosa*, Rss.,						×									64
65	*Spiroplecta biformis* (P. & J.),													×		65
66	*Gaudryina baccata*, Schwag.,				×		×									66
67	,, *pupoides*, d'Orb.,	×												×	×	67
68	,, *siphonella*, Rss.,	×			×	×										68
69	*Clavulina communis*, d'Orb.,			×			×									69

TABLE III.—RED CLAY—*Continued.*

		North Atlantic. St. 5; — 2740 fath.	North Atlantic. St. 9; — 3150 fath.	Southern Ocean. St. 160; — 2600 fath.	Chinese Sea. St. 206; — 2100 fath.	North Pacific. St. 238; — 3950 fath.	North Pacific. St. 241; — 2300 fath.	North Pacific. St. 244; — 2900 fath.	North Pacific. St. 253; — 3125 fath.	North Pacific. St. 256; — 2950 fath.	North Pacific. St. 265; — 2900 fath.	South Pacific. St. 179; — 2925 fath.	South Pacific. St. 276; — 2350 fath.	South Pacific. St. 285; — 2375 fath.	South Pacific. St. 296; — 1825 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
70	*Clavulina parisiensis*, d'Orb.,								×							70
71	*Bulimina aculeata*, d'Orb.,	×														71
72	„ *affinis*, d'Orb.,								?							72
73	„ *buchiana*, d'Orb.,												×	×		73
74	*Virgulina schreibersiana*, Czjz.,	×		×					×				×			74
75	,, *squamosa*, d'Orb.,			×					×							75
76	„ *subdepressa*, Br.,							-							×	76
77	,, *texturata*, Br.,														×	77
78	*Bolivina punctata*, d'Orb.,	×					×									78
79	*Pleurostomella subnodosa*, Rss.,														×	79
80	*Cassidulina subglobosa*, Br.,	×		×			×			×		×	×		×	80
81	*Ehrenbergina hystrix*, Br.,											×				81
82	,, *serrata*, Rss.,						×								×	82
83	*Chilostomella ovoidea*, Rss.,				×		×		×						×	83
84	*Lagena acuta* (Rss.),						×						×	×	×	84
85	„ *acuticosta*, Rss.,						×						×			85
86	,, *alveolata*, Br.,	×					×									86
87	,, ,, var. *substriata*, Br.,												×			87
88	„ ,, var. *caudigera*, Br.,														×	88
89	,, *apiculata*, Rss.,	×					×						×			89
90	,, *aspera*, Rss.,						×									90
91	,, *auriculata*, Br.,	×					×					×	×		×	91
92	,, ,, var. *costata*, Br.,						×						×			92
93	,, *bicarinata* (Terq.),	×														93
94	,, *desmophora*, Ry. J.,	×														94
95	,, *exsculpta*, Br.,			×			×									95
96	,, *feildeniana*, Br.,						×									96
97	,, *fimbriata*, Br.,			×			×						×			97
98	,, *formosa*, Schwag.,	×										×	×			98
99	,, *globosa* (Montag.),	×		×								×	×		×	99
100	,, *gracillima* (Seg.),			×	×		×					×	×		×	100
101	,, *gracilis*, Will.,			×								×	×		×	101
102	,, *hertwigiana*, Br.,			×												102
103	,, *hexagona* (Will.),						×						×			103
104	,, *hispida* (Rss.),						×								×	104
105	,, *interrupta* (Will.),												×			105
106	,, *lagenoides* (Will.),	×														106
107	,, *lævigata* (Rss.),				×		×		×				×			107
108	,, *lævis* (Montag.),						×						×		×	108
109	,, *longispina*, Br.,	×		×								×	×		×	109
110	,, *marginata* (W. & B.),						×		×			×	×		×	110
111	,, *orbignyana* (Seg.),						×		×			×	×		×	111
112	,, *ovum* (Ehr.),	×					×									112
113	,, *plumigera*, Br.,												×			113
114	,, *quadralata*, Br.,			×												114

TABLE III.—RED CLAY—*Continued.*

		North Atlantic. St. 5; — 2740 fath.	North Atlantic. St. 9; — 3150 fath.	Southern Ocean. St. 160; — 2600 fath.	Chinese Sea. St. 206; — 2100 fath.	North Pacific. St. 238; — 3950 fath.	North Pacific. St. 241; — 2300 fath.	North Pacific. St. 244; — 2900 fath.	North Pacific. St. 253; — 3125 fath.	North Pacific. St. 256; — 2950 fath.	North Pacific. St. 265; — 2900 fath.	South Pacific. St. 179; — 2325 fath.	South Pacific. St. 276; — 2350 fath.	South Pacific. St. 285; — 2375 fath.	South Pacific. St. 296; — 1825 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
115	*Lagena quinquelatera*, Br.,												×			115
116	,, *seminiformis*, Schwag.,														×	116
117	,, *seminuda*, Br.,														×	117
118	,, *semistriata*, Will.,						×		×			×	×			118
119	,, *squamosa* (Montag.),						×									119
120	,, *squamoso-marginata*, P. & J.,														×	120
121	,, *staphyllearia*, Schwag.,			×												121
122	,, *stelligera*, Br.,	×		×			×						×			122
123	,, *striata* (d'Orb.),	×		×			×					×				123
124	,, *striatopunctata*, P. & J.,						×					×				124
125	,, *sulcata* (W. & J.),	×		×			×					×	×			125
126	,, *trigono-marginata*, P. & J.,						×									126
127	,, *truncata*, Br.,	×													×	127
128	*Nodosaria abyssorum*, Br.,														×	128
129	,, (D.) *communis*, d'Orb.,	×											×			129
130	,, (Gl.) *lævigata*, d'Orb.,														×	130
131	,, (D.) *mucronata*, Neug.,												×			131
132	,, *scalaris* (Batsch),						×									132
133	*Marginulina glabra*, d'Orb.,	×														133
134	*Cristellaria acutauricularis* (F. & M.),												×			134
135	,, *convergens*, Bornem.,	×														135
136	*Polymorphina angusta*, Egger,						×					×	×			136
137	,, *lactea* (W. & J.),						×						×			137
138	,, *lanceolata*, Rss.,												×		×	138
139	,, *longicollis*, Br.,														×	139
140	,, *rotundata*, Born.,														×	140
141	*Uvigerina asperula*, Czjz.,			×			×								×	141
142	,, *pygmæa*, d'Orb.,			×											×	142
143	*Globigerina bulloides*, d'Orb.,	×	×	×	×		×		×	×	×		×	×	×	143
144	,, *conglobata*, Br.,	×										×	×		×	144
145	,, *digitata*, Br.,												×		×	145
146	,, *dubia*, Egger.,	×			×		×					×	×		×	146
147	,, *æquilateralis*, Br.,	×			×							×	×		×	147
148	,, *inflata*, d'Orb.,	×	×	×			×		×	×					×	148
149	,, *pachyderma* (Ehr.),		?						×		×					149
150	,, *rubra*, d'Orb.,	×	×													150
151	,, *sacculifera*, Br.,	×										×	×		×	151
152	*Orbulina universa*, d'Orb.,	×	×	×			×	×	×			×			×	152
153	*Hastigerina pelagica* (d'Orb.),											×				153
154	*Pullenia obliquiloculata*, P. & J.,	×			×							×	×			154
155	,, *quinqueloba*, Rss.,	×		×			×					×	×		×	155
156	,, *sphæroides* (d'Orb.),	×		×			×			×			×		×	156
157	*Sphæroidina dehiscens*, P. & J.,	×			×							×	×		×	157
158	,, *bulloides*, d'Orb.,			×			×									158
159	*Truncatulina haidingerii* (d'Orb.),														×	159

TABLE III.—RED CLAY—*Continued.*

		North Atlantic. St. 5; — 2740 fath.	North Atlantic. St. 9; — 3150 fath.	Southern Ocean. St. 160; — 2600 fath.	Chinese Sea. St. 206; — 2100 fath.	North Pacific. St. 238; — 3950 fath.	North Pacific. St. 241; — 2300 fath.	North Pacific. St. 244; — 2900 fath.	North Pacific. St. 253; — 3125 fath.	North Pacific. St. 256; — 2950 fath.	North Pacific. St. 265; — 2900 fath.	South Pacific. St. 179; — 2325 fath.	South Pacific. St. 276; — 2350 fath.	South Pacific. St. 285; — 2375 fath.	South Pacific. St. 296; — 1825 fath.	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
160	*Truncatulina humilis*, Br.,												×		×	160
161	,, *lobatula* (W. & J.),	×			×			×								161
162	,, *pygmæa*, Hantk.,	×	×	×			×		×	×		×	×	×	×	162
163	,, *tumidula*, Br.,	×														163
164	,, *ungeriana* (d'Orb.),			×			×									164
165	,, *wuellerstorfi* (Schw.),														×	165
166	*Pulvinulina canariensis* (d'Orb.),														×	166
167	,, *crassa* (d'Orb.),	×	×												×	167
168	,, *exigua*, Br.,	×		×			×					×	×		×	168
169	,, *favus*, Br.,											×	×		×	169
170	,, *micheliniana* (d'Orb.),	×	×	×			×	×		×		×			×	170
171	,, *menardii* (d'Orb.),	×	×		×		×					×			×	171
172	,, *patagonica* (d'Orb.),							×								172
173	,, *pauperata*, P. & J.,														×	173
174	,, *tumida*, Br.,	×			×							×	×			174
175	,, *umbonata*, Rss.,								×				×			175
176	*Rotalia beccarii* (Linn.),									×			×			176
177	,, *orbicularis*, d'Orb.,			×									×			177
178	,, *soldanii*, d'Orb.,	×										×			×	178
179	*Nonionina depressula* (W. & J.),	×		×			×									179
180	,, *pompilioides* (F. & M.),											×	×	×	×	180
181	,, *umbilicatula* (Montag.),	×		×			×		×			×	×		×	181
182	*Polystomella striatopunctata* (F. & M.),			×												182

TABLE IV.—THE SHALLOW-WATER FORAMINIFERA OF HIGH LATITUDES—NORTH AND SOUTH.

The first division of Table IV. embodies the results of the examination of the most southerly shallow-water dredgings taken during the Challenger cruise—all those, namely, south of about lat. 50° S. The list embraces 137 "species," the salient genera being *Biloculina*, *Miliolina*, *Reophax*, *Haplophragmium*, *Cassidulina*, *Lagena*, *Uvigerina*, *Globigerina*, *Pullenia*, *Truncatulina*, *Nonionina*, and *Polystomella*.

The physical and biological conditions of the Southern Ocean differ greatly from those of similar latitudes in northern seas; and the comparative absence of land south of lat. 45° S. gives a peculiar interest to the marginal fauna of Kerguelen Island, Heard Island, the Falkland Islands and similar localities.

The Stations included in the first section of the Table yield the nearest approach we have to a view of an antarctic shallow-water fauna. It is unfortunately impossible to furnish any precisely corresponding series from the northern hemisphere for purposes of comparison; but, notwithstanding the difference in actual latitude, a number of interesting facts are brought to light by the collateral tabular arrangement of the Foraminifera from similar depths in the Arctic Seas.

The second division of the Table forms a summary of what is known concerning the distribution of Foraminifera within the Arctic Circle; or, more strictly, between lat. 65° and 83° 19′ N. It comprises 111 "species," the prominent generic types being the same as the foregoing, omitting *Pullenia* and adding *Polymorphina* and *Textularia*.

Comparing the two sections of the Table, it will be found that eleven genera appear in the southern division which are absent from the northern; whilst ten genera occur in the northern and not in the southern. These for the most part are represented individually by rare examples of a single species; but there are some exceptions, the most important of which are *Articulina*, *Clavulina*, and *Sagrina* in the southern list, and the Textularian genera *Verneuilina*, *Bigenerina*, and *Spiroplecta*, together with *Polymorphina* and *Operculina* in the northern series. Judging from a somewhat wider area than that embraced by the Table, it appears as though *Uvigerina*, and its dimorphous modification *Sagrina*, take the place of *Polymorphina* in southern latitudes, and *Clavulina* that of *Bigenerina*; whilst the porcellanous forms display a more varied development. The northern region, on the other hand, is much richer in the Textularian types, in *Polymorphinæ* and *Nonioninæ*. Taking the entire list, thirty-two genera and sixty species are common to both areas.

A. Kerguelen Island. Three Stations, 149, D. E. I.; lat. between 49° and 50° S.; depth, 20 to 120 fathoms.

B. Southern Ocean, west of Heard Island. Station 150; lat. 52° 4′ S.; depth 150 fathoms.

C. Southern Ocean, off Heard Island. Station 151; lat. about 53° S.; depth, 75 fathoms.

D. West coast of Patagonia. Stations 308 and 309; lat. 50° 10′, and 50° 56′ S.; depth 40 to 175 fathoms.

E. Sarmiento Channel. Station 310; lat. 51° 30′ S.; depth, 400 fathoms.

F. South-west of Patagonia. Station 311; lat. 52° 50′ S.; depth, 245 fathoms.

G. Magellans Strait. Station 313; lat. 52° 20′ S.; depth, 55 fathoms.

H. Falkland Islands. Station 315 A; Stanley Harbour; lat. 51° 32′ S.; depth, 6 fathoms.

I. Baffin's Bay and Smith Sound. Lat. 77° 15′ to 79° 45′ N.; depth, 13 to 220 fathoms; sixteen soundings. British North-Polar Expedition.

J. North of Smith Sound. Lat. 81° 41′ to 83° 19′ N.; greatest depth, 72 fathoms; eight samples, British North-Polar Expedition.

K. Coast of Norway. Lat. 65° to 71° N.; depth, 20 to 300 fathoms; eight soundings. Parker and Jones.

L. Hunde Islands, Davis Strait. Lat. 68° 50′ N.; depth, 25 to 70 fathoms; five soundings. Parker and Jones.

M. Novaya Zemlya Seas. Lat. 73° to 77° N.; depth, 10 to 219 fathoms; thirteen soundings. Austro-Hungarian North-Polar Expedition, and Capt. Markham's Cruise.

N. Franz-Josef Land. Lat. 79° to 80° N.; depth, 89 to 145 fathoms; ten soundings. Austro-Hungarian North-Polar Expedition.

TABLE IV.—The Shallow-Water Foraminifera of High Latitudes—North and South.

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
		Kerguelen Island. St. 149 D, E, I; — 20 to 120 fath.	Southern Ocean. St. 150, lat. 52° 4′ S.; — 150 fath.	Heard Island. St. 151; — 75 fath.	West Coast of Patagonia. St. 308, 309; — 40 to 175 fath.	Sarmiento Channel. St. 310; — 400 fath.	South-west of Patagonia. St. 311; — 245 fath.	Magellans Strait. St. 313; — 55 fath.	Falkland Islands. St. 315A; — 6 fath.	Baffin's Bay and Smith Sound. Lat. 77° 15′ to 79° 45′ N.; — 13 to 220 fath.	North of Smith Sound. Lat. 81° 40′ to 83° 19′ N.; deepest 72 fath.	Coast of Norway. Lat. 65° to 71° N.; — 20 to 300 fath.	Hunde Islands, Davis Strait. Lat. 68° 50′ N.; — 25 to 70 fath.	Novaya Zemlya Seas. Lat. 73° to 77° N.; — 10 to 219 fath.	Franz-Josef Land. Lat. 79° to 80° N.; — 89 to 145 fath.	
1	*Nubecularia inflata*, Br.,	×														1
2	*Biloculina bulloides*, d'Orb.,													×		2
3	,, *depressa*, d'Orb.,	×	×		×		×									3
4	,, *elongata*, d'Orb.,	×		×			×									4
5	,, *ringens* (Lamk.),	×			×	×	×	×				×		×		5
6	,, *sphæra*, d'Orb.,	×	×	×	×	×	×									6
7	*Spiroloculina planulata* (Lamk.),				×											7
8	*Miliolina agglutinans* (d'Orb.),												×	×		8
9	,, *auberiana* (d'Orb.),						×									9
10	,, *bucculenta*, Br.,	×														10
11	,, *circularis* (Born.),	×														11
12	,, *ferussacii* (d'Orb.),												×			12
13	,, *labiosa* (d'Orb.),								×							13
14	,, *oblonga* (Montag.),	×					×	×	×				×			14
15	,, *pygmæa* (Rss.),				×											15
16	,, *seminulum* (Linn.),	×		×	×	×	×	×	×	×	×	×	×	×	×	16
17	,, *subrotunda* (Mont.),			×				×		×			×	×		17
18	,, *tricarinata* (d'Orb.),									×	×		×	×	×	18
19	*Articulina funalis*, Br.,	×		×												19
20	,, var. *inornata*, Br.,	×														20
21	*Ophthalmidium inconstans*, Br.,	×														21
22	*Planispirina celata* (Costa),				×											22
23	*Cornuspira foliacea*, Phil.,										×		×			23
24	,, *involvens*, Rss.,	×								×	×			×	×	24
25	*Pelosina variabilis*, Br.,														×	25
26	*Technitella legumen*, Norm.,	×														26
27	*Saccammina sphærica*, M. Sars.,	×													×	27
28	*Hyperammina arborescens* (Norm.),													×	×	28
29	,, *elongata*, Br.,									×				×	×	29
30	,, *ramosa*, Br.,				×									×	×	30
31	,, *vagans*, Br.,	×														31
32	*Rhabdammina abyssorum*, M. Sars.,													×	×	32
33	,, *discreta*, Br.,	×														33
34	*Reophax arctica*, Br.,													×		34
35	,, *ampullacea*, Br.,	×														35
36	,, *difflugiformis*, Br.,	×				×								×	×	36
37	,, *dentaliniformis*, Br.,	×														37
38	,, *fusiformis* (Will.),									×				×		38
39	,, *nodulosa*, Br.,														×	39
40	,, *pilulifera*, Br.,					×										40

TABLE IV.—HIGH LATITUDES—*continued.*

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
		Kerguelen Island. St. 149 D, E, I; — 20 to 120 fath.	Southern Ocean. St. 150, lat. 52° 4′ S.; — 150 fath.	Heard Island. St. 151; — 75 fath.	West Coast of Patagonia. St. 308, 309; — 40 to 175 fath.	Sarmiento Channel. St. 310; — 400 fath.	South-west of Patagonia. St. 311; — 245 fath.	Magellans Strait. St. 313; — 55 fath.	Falkland Islands. St. 315A; — 6 fath.	Baffin's Bay and Smith Sound. Lat. 77° 15′ to 79° 45′ N.; — 13 to 220 fath.	North of Smith Sound. Lat. 81° 40′ to 83° 19′ N.; deepest 72 fath.	Coast of Norway. Lat. 65° to 71° N.; — 20 to 300 fath.	Hunde Islands, Davis Strait. Lat. 68° 50′ N.; — 25 to 70 fath.	Novaya Zemlya Seas. Lat. 73° to 77° N.; — 10 to 219 fath.	Franz-Josef Land. Lat. 79° to 80° N.; — 89 to 145 fath.	
41	*Reophax scorpiurus*, Montf.,	×		×	×	×	×			×			×	×	×	41
42	,, *spiculifera*, Br.,	×														42
43	*Haplophragmium canariense* (d'Orb.),	×		×	×	×	×	×		×	×	×	×	×	×	43
44	,, *fontinense*, Terq.,				×											44
45	,, *globigeriniforme* (P. & J.),												×		×	45
46	,, *glomeratum*, Br.,	×								×	×			×	×	46
47	,, *latidorsatum* (Born.),						×								×	47
48	,, *nanum*, Br.,													×	×	48
49	,, *scitulum*, Br.,					×										49
50	*Hippocrepina indivisa*, Park.,													×		50
51	*Hormosina globulifera*, Br.,					×										51
52	*Ammodiscus charoides* (J. & P.),	×														52
53	,, *gordialis* (J. & P.),	×				×							×	×	×	53
54	,, *shoneanus*, Sidd.,	×														54
55	,, *tenuis*, Br.,					×										55
56	*Trochammina nitida*, Br.,													×	×	56
57	,, *squamata*, J. & P.,				×	×							×			57
58	*Cyclammina cancellata*, Br.,				×	×										58
59	*Textularia agglutinans*, d'Orb.,											×	×	×	×	59
60	,, *aspera*, Br.,				×											60
61	,, *concava* (Karr.),				×											61
62	,, *gramen*, d'Orb.,				×											62
63	,, *pygmæa*, d'Orb.,											×				63
64	*Bigenerina nodosaria*, d'Orb.,												×			64
65	*Verneuilina polystropha* (Rss.),									×			×	×		65
66	*Spiroplecta biformis* (P. & J.),									×			×	×	×	66
67	*Valvulina conica*, P. & J.,											×				67
68	*Clavulina communis*, d'Orb.,				×	×	×									68
69	*Bulimina aculeata*, d'Orb.,			×								×				69
70	,, *elegantissima*, d'Orb.,								×					×		70
71	,, *marginata*, d'Orb.,				×											71
72	,, *ovata*, d'Orb.,									×	×					72
73	,, *pupoides*, d'Orb.,						×									73
74	,, *pyrula*, d'Orb.,				×	×	×					×				74
75	,, *subteres*, Br.,				×					×	×		×	×		75
76	*Virgulina schreibersiana*, Czjz.,			×						×			×	×	×	76
77	,, *squamosa*, d'Orb.,											×	×			77
78	*Bolivina punctata*, d'Orb.,			×	×					×				×		78
79	,, *robusta*, Br.,					×										79
80	*Cassidulina bradyi*, Norm.,				×											80
81	,, *crassa*, d'Orb.,	×	×	×	×	×	×			×	×		×	×	×	81

TABLE IV.—HIGH LATITUDES—*Continued.*

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
		Kerguelen Island. St. 149 D, E, I; — 20 to 120 fath.	Southern Ocean. St. 150, lat. 52° 4′ S.; — 150 fath.	Heard Island. St. 151; — 75 fath.	West Coast of Patagonia. St. 308, 309; — 40 to 175 fath.	Sarmiento Channel. St. 310; — 400 fath.	South-west of Patagonia. St. 311; — 245 fath.	Magellans Strait. St. 313; — 55 fath.	Falkland Islands. St. 315A; — 6 fath.	Baffin's Bay and Smith Sound. Lat. 77° 15′ to 79° 45′ N.; — 13 to 220 fath.	North of Smith Sound. Lat. 81° 40′ to 83° 19′ N.; deepest 72 fath.	Coast of Norway. Lat. 65° to 71° N.; — 20 to 300 fath.	Hunde Islands, Davis Strait. Lat. 68° 50′ N.; — 25 to 70 fath.	Novaya Zemlya Seas. Lat. 73° to 77° N.; — 10 to 219 fath.	Franz-Josef Land. Lat. 79° to 80° N.; — 89 to 145 fath.	
82	*Cassidulina lævigata*, d'Orb,				×		×			×	×	×	×	×	×	82
83	,, *parkeriana*, Br.,				×											83
84	,, *subglobosa*, Br.,	×	×					×								84
85	*Ehrenbergina pupa* (d'Orb.),				×											85
86	*Lagena acuta* (Rss.),	×		×					×							86
87	,, *acuticosta*, Rss.,			×												87
88	,, *apiculata*, Rss.,			×						×	×		×	×		88
89	,, *clavata* (d'Orb.),			×												89
90	,, *distoma*, P. & J.,	×			×		×					×		×		90
91	,, *feildeniana*, Br.,									×						91
92	,, *formosa*, var. *favosa*, Br.,		×													92
93	,, *globosa* (Montag.),								×	×			×	×		93
94	,, *gracillima* (Seg.),	×		×								×		×		94
95	,, *gracilis*, Will.,				×									×		95
96	,, *hispida*, Reuss,				×		×									96
97	,, *interrupta*, Will.,	×		×												97
98	,, *lævigata* (Rss.),	×	×	×				×	×					×	×	98
99	,, *lævis* (Montag.),	×	×	×	×	×	×	×	×	×		×		×	×	99
100	,, *lagenoides* (Will.),													×	×	100
101	,, *linecata* (Will.),	×	×													101
102	,, *marginata* (W. & B.),	×		×	×				×	×	×	×	×			102
103	,, *melo* (d'Orb.),											×	×			103
104	,, *orbignyana* (Seg.),								×					×		104
105	,, *quadricostulata*, Rss.,	×														105
106	,, *semimarginata* (Rss.),			×												106
107	,, *semistriata*, Will.,	×			×								×	×		107
108	,, *squamosa* (Montag.),	×	×	×						×		×	×	×	×	108
109	,, *staphyllearia* (Schwag.),	×		×												109
110	,, *stelligera*, Br.,	×														110
111	,, *striata* (d'Orb.),	×		×	×		×		×	×						111
112	,, *striatopunctata*, P. & J.,						×			×			×	×		112
113	,, *sulcata* (W. & J.),	×	×	×	×			×	×	×	×	×	×	×		113
114	*Nodosaria calomorpha*, Rss.,	×							×							114
115	,, (D.) *communis*, d'Orb.,	×			×	×				×		×	×			115
116	,, (D.) *guttifera*, d'Orb.,											×				116
117	,, (Gl.) *lævigata*, d'Orb.,				×		×			×		×				117
118	,, (D.) *mucronata*, Neug.,														×	118
119	,, (D.) *pauperata*, d'Orb.,						×			×		×			×	119
120	,, *pyrula*, d'Orb.,						×									120
121	,, *radicula* (Linn.),											×	×	×	×	121
122	*Marginulina glabra*, d'Orb.,				×											122

TABLE IV.—HIGH LATITUDES—*Continued.*

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
		Kerguelen Island. St. 149 D, E, I; — 20 to 120 fath.	Southern Ocean. St. 150, lat. 52° 4′ S.; — 150 fath.	Heard Island. St. 151; — 75 fath.	West Coast of Patagonia. St. 308, 309; — 40 to 175 fath.	Sarmiento Channel. St. 310; — 400 fath.	South-west of Patagonia. St. 311; — 245 fath.	Magellans Strait. St. 313; — 55 fath.	Falkland Islands. St. 315A; — 6 fath.	Baffin's Bay and Smith Sound. Lat. 77° 15′ to 79° 45′ N.; — 13 to 220 fath.	North of Smith Sound. Lat. 81° 40′ to 83° 19′ N.; deepest 72 fath.	Coast of Norway. Lat. 65° to 71° N.; — 20 to 300 fath.	Hunde Islands, Davis Strait. Lat. 68° 50′ N.; — 25 to 70 fath.	Novaya Zemlya Seas. Lat. 75° to 77° N.; — 10 to 219 fath.	Franz-Josef Land. Lat. 79° to 80° N.; — 89 to 145 fath.	
123	*Marginulina lituus*, d'Orb.,											×				123
124	*Vaginulina linearis* (Montag.),											×				124
125	,, *legumen* (Linn.),	×														125
126	*Cristellaria acutauricularis* (F. & M.),				×											126
127	,, *crepidula* (F. & M.),												×			127
128	,, *cultrata* (Montf.),	×			×							×				128
129	,, *reniformis*, d'Orb.,				×											129
130	,, *rotulata* (Lamk.),					×	×			×		×				130
131	*Polymorphina acuminata*, d'Orb.,									×						131
132	,, *compressa*, d'Orb.,									×		×	×	×		132
133	,, *lactea* (W. & J.),									×	×	×	×	×		133
134	,, *oblonga*, d'Orb.,													×		134
135	,, *problema*, d'Orb.,									×						135
136	,, *rotundata* (Born.),									×						136
137	*Uvigerina angulosa*, Will.,	×	×		×		×					×				137
138	,, *asperula*, Czjz.,	×	×				×									138
139	,, *brunnensis*, Kar.,	×					×									139
140	,, *canariensis*, d'Orb.,				×											140
141	,, *pygmæa*, d'Orb.,				×					×		×	×	×	×	141
142	,, *tenuistriata*, Rss.,			×	×											142
143	*Sagrina raphanus*, P. & J.,	×														143
144	,, *dimorpha*, P. & J.,				×	×										144
145	*Globigerina bulloides*, d'Orb.,	×	×	×	×	×	×	×		×		×	×	×	×	145
146	,, *dutertrei*, d'Orb.,		×													146
147	,, *inflata*, d'Orb.,				×						×					147
148	,, *pachyderma* (Ehr.),									×	×			×	×	148
149	*Orbulina universa*, d'Orb.,				×									×		149
150	*Pullenia quinqueloba*, Rss.,	×	×	×	×											150
151	,, *sphæroides* (d'Orb.),				×							×		×		151
152	*Spirillina obconica*, Br.,	×														152
153	,, *vivipara*, Ehr.,	×								×	×	×	×			153
154	,, *tuberculata*, Br.,	×				×										154
155	*Patellina corrugata*, Will.,	×		×					×	×	×		×	×		155
156	*Discorbina araucana* (d'Orb.),	×														156
157	,, *bertheloti* (d'Orb.),													×		157
158	,, *globularis* (d'Orb.),				×			×				×	×			158
159	,, *obtusa* (d'Orb.),									×			×			159
160	,, *parisiensis* (d'Orb.),	×		×												160
161	,, *rosacea* (d'Orb.),			×			×									161
162	,, *vilardeboana* (d'Orb.),			×												162
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TABLE IV.—HIGH LATITUDES—*Continued.*

		A: Kerguelen Island. St. 149 D, 1; — 20 to 120 fath.	B: Southern Ocean. St. 150, lat. 52° 4′ S.; — 150 fath.	C: Heard Island. St. 151; — 75 fath.	D: West Coast of Patagonia. St. 308, 309; — 40 to 175 fath.	E: Sarmiento Channel. St. 310; — 400 fath.	F: South-west of Patagonia. St. 311; — 245 fath.	G: Magellans Strait. St. 313; — 55 fath.	H: Falkland Islands. St. 315A; — 6 fath.	I: Baffin's Bay and Smith Sound. Lat. 77° 15′ to 79° 45′ N.; — 13 to 220 fath.	J: North of Smith's Sound. Lat. 81° 40′ to 83° 19′ N.; deepest 72 fath.	K: Coast of Norway. Lat. 65° to 71° N.; — 20 to 300 fath.	L: Hunde Islands, Davis Strait. Lat. 68° 50′ N.; — 25 to 70 fath.	M: Novaya Zemlya Seas. Lat. 73° to 77° N.; — 10 to 219 fath.	N: Franz-Josef Land. Lat. 79° to 80° N.; — 89 to 145 fath.	
164	*Truncatulina haidingerii* (d'Orb.),				×											164
165	,, *lobatula* (W. & J.),	×	×	×	×		×	×	×	×	×	×	×	×	×	165
166	,, *refulgens* (Montf.),				×		×									166
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168	,, *variabilis*, d'Orb.,				×		×									168
169	*Anomalina coronata*, P. & J.,				×							×				169
170	*Pulvinulina karsteni* (Rss.),								×	×	×		×	×	×	170
171	,, *micheliniana* (d'Orb.),									×			×			171
172	,, *punctulata* (d'Orb.),											×				172
173	,, *umbonata*, Rss.,				×		×									173
174	*Rotalia beccarii* (Linn.),				×				×							174
175	,, *clathrata*, Br.,				×											175
176	*Nonionina asterizans* (F. & M.),												×			176
177	,, *depressula* (W. & J.),					×				×	×		×	×	×	177
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180	,, *scapha* (F. & M.),				×	×	×			×	×		×	×		180
181	,, *stelligera*, d'Orb.,						×			×	×	×	×	×	×	181
182	,, *turgida* (Will.),													×		182
183	,, *umbilicatula* (Montag.),				×					×		×		×	×	183
184	*Polystomella arctica*, P. & J.,									×	×		×	×	×	184
185	,, *crispa* (Linn.),	×						×	×				×			185
186	,, *macella* (F. & M.),	×							×							186
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TRACK OF
H.M.S. CHALLENGER
Dec.r 1872 to May 1876.
Shewing the Dredging and Trawling Stations
The Stations from which the Foraminifera of the Deposits have been determined, are marked in red.
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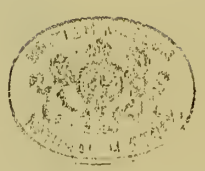
MAP
showing the Areas explored by the
"PORCUPINE" AND "KNIGHT ERRANT" EXPEDITIONS
AND
BRITISH AND AUSTRO-HUNGARIAN NORTH POLAR EXPEDITIONS.

The Stations from which the Foraminifera of the deposits have been determined are marked in red. The Knight Errant Stations are distinguished by a square mark.